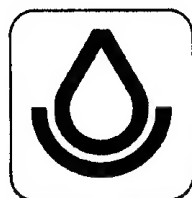


SOIL SURVEY

Long Valley Area Arizona



UNITED STATES DEPARTMENT OF AGRICULTURE
Forest Service and Soil Conservation Service
in cooperation with
ARIZONA AGRICULTURAL EXPERIMENT STATION

Issued June 1974

Fieldwork for this survey was completed in 1966. Soil names and descriptions were approved in 1967. Unless otherwise indicated, all statements in this publication refer to conditions in the Area in 1966. This survey was made cooperatively by the Forest Service, the Soil Conservation Service, and the Arizona Agricultural Experiment Station to furnish information needed in managing the Coconino National Forest. It is part of the technical assistance furnished to the Coconino and Verde Soil Conservation Districts.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of the Long Valley Area contains information that can be applied in managing forests, watersheds, and rangeland; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for wildlife and recreational uses.

Locating Soils

All the soils of the Long Valley Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the Area in alphabetic order by map symbol. It shows the page where each kind of soil is described and identifies each soil according to capability subclass and management group.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils

that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Foresters and others can refer to the section "Timber Management," in which the soils of the Area are grouped according to their suitability for trees.

Watershed specialists and hydrologists can read about hydrologic factors of the soils in the section "Watershed Management."

Game managers, sportsmen, and others concerned with wildlife can find information about soils and wildlife in the section "Wildlife Management."

Range managers, ranchers, and others interested in range can find, under "Range Management," groupings of the soils according to their suitability for herbage production and also the plants that grow on each soil.

Recreation planners and others concerned with recreation development can read about the soil properties that affect the choice of recreation areas in the section "Recreation Sites."

Engineers and builders can find, under "Soils and Engineering," tables that give estimates of soil properties and information about soil features that affect engineering practices and structures.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in the Long Valley Area may be especially interested in the section "Soil Management Areas," where broad patterns of soils are described. They may also be interested in "Part I: The Area," which gives additional information about the survey area.

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SOIL SURVEY OF LONG VALLEY AREA, ARIZONA

BY L. D. WHEELER, JR., AND JOHN A. WILLIAMS, FOREST SERVICE

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UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE AND SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE ARIZONA AGRICULTURAL EXPERIMENT STATION

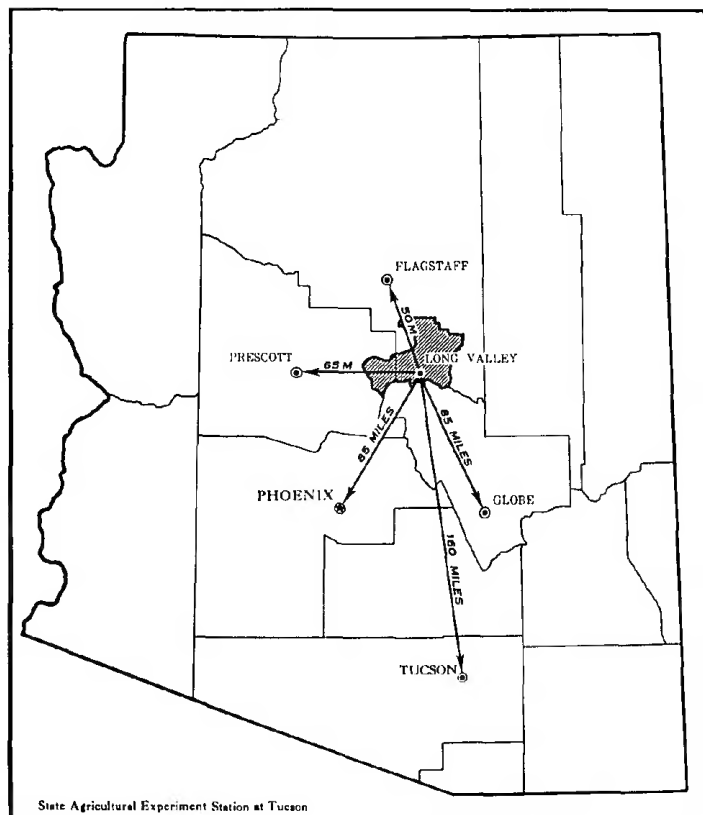


Figure 1.—Location of Long Valley Area in Arizona.

Part I: The Area

THE LONG VALLEY AREA is in the north-central part of Arizona. It is about 48 miles long and 36 miles wide. It borders the Beaver Creek Area (10).¹ The total land area is about 626,623 acres, or approximately 980 square miles. About three-fourths of the Area is in Coconino County, and the rest is in Yavapai County (fig. 1). The longest axis runs northeast to southwest.

The closest settlements are Camp Verde at the southwest corner, and Happy Jack near the northwest corner.

¹ Italic numbers in parentheses refer to Literature Cited, p. 76.

Sedona is about 20 miles west of the Area, Flagstaff is about 40 miles north, and Winslow is about 26 miles to the northeast. Forest Highway 10, or State Highway 87, traverses the central and eastern parts of the Area. Forest Highway 3, or State Highway 209, enters the northern part of the Area and intersects Forest Highway 10 at Clints Well. Forest Highway 9, or State Highway 279, enters the Area at Camp Verde and crosses the extreme southwestern part. Other secondary roads provide access to most of the Area.

The Area is wholly within the Coconino National Forest. It consists of the Blue Ridge Ranger District and parts of the Long Valley and Beaver Creek Districts. About 86 percent of the land is owned by the Federal Government, and the rest by private owners or the State of Arizona.

Physiography, Relief, and Drainage

The landscape is one of low hills and undulating valleys, a high plateau, escarpments, rims, mountain peaks, and deep, rugged canyons. About three-fourths of the Area is in the Grand Canyon section of the Colorado Plateau physiographic province (3). The rest is in the Mexican Highlands section of the Basin and Range physiographic province. Elevations range from 3,000 feet near Childs to 8,500 feet on the buttes and peaks on the plateau. The average elevation of the basin and valley is about 3,500 feet, and that of the plateau is 7,100 feet. Prominent landscape features are the Mogollon Rim, Leonard Canyon, West Clear Creek Canyon, East Clear Creek Canyon, Jacks Canyon, Devils Windpipe, Hackberry Mountain, Baker Butte, and Taul Peaks. Hutch Mountain at an elevation of 8,505 feet and Buck Mountain at 7,590 feet are along the western and northern boundaries.

The Coconino Plateau, the Verde Valley, and the Mogollon Rim and Breaks are the three distinct landforms of the Area.

The slope of the Coconino Plateau conforms with the regional dip of the rocks, which is north and east. The terrain in the northern part is characterized by low hills, buttes, ridges, narrow valleys, undulating flatlands, and many small drainageways. A broad, gently rolling, tilted plateau extends from the Mogollon Rim to the center of the Area. This part of the plateau is dissected by deep, steep-walled canyons. There are some hills and buttes.

The terrain in the western part of the Area, the Verde Valley, is characterized by terraces, alluvial fans, bottom land, low mesas, ridges, and draws.

The Mogollon Rim and Breaks extend from the Verde Valley to the Coconino Plateau. The Rim rises several hundred feet above the lower country. It is a series of vertical cliffs, escarpments, and very steep slopes broken by canyons that originate in the plateau. The Breaks consists largely of rough and broken mountains, canyons, undulating mesas, basins, and swales.

Drainage of the Area flows into the Verde and Little Colorado Rivers. About 60 percent of the Area is in the Verde Watershed and 40 percent is in the Little Colorado Watershed. East Clear Creek, Leonard Canyon, and Jacks Canyon are tributaries of the Little Colorado River. Willow Valley, West Clear Creek, and Fossil Creek are tributaries of the Verde River. East Clear Creek, West Clear Creek, and Fossil Creek are perennial streams. Streamflow in Fossil Creek, however, is slight because the water is captured at its source and piped through a number of hydroelectric plants. The parts of these major stream courses on the Coconino Plateau are strongly incised in deep and spectacular canyons.

Rock Types

The rocks of the Area are igneous and sedimentary. The igneous rocks are of volcanic origin. The sedimentary rocks are the Kaibab, Coconino, Moenkopi, and Verde Formations.

Nearly two-thirds of the Area is covered or underlain by rocks of volcanic origin, dominantly basalt and cinders, but also rhyolite, andesite, and tuff. These materials occur as old lava flows and cinder cones.

The west-central and northwestern parts of the Area on the Coconino Plateau are almost entirely basalt and cinders. The cinders are commonly localized around cones that form some of the prominent high elevations. The rest of this part of the Area is largely basalt flows that in many places are somewhat thin caps overlying the Kaibab Formation.

A large part of the Area below the Mogollon Rim is covered with basalt and also with rhyolite, andesite, and tuff.

About 30 percent of the Area has exposures of, or is underlain by, sedimentary rocks. In the central part there is considerable interbedding of limestone and sandstone, mostly of the Kaibab Formation, but some from the Coconino Formation. The steep slopes of Blue Ridge are sandstones and shales of the Moenkopi Formation.

The eastern part of the survey area is underlain largely by the Kaibab Formation and the Coconino Sandstone. These two formations are interbedded in this part of the Area, but the Kaibab Formation appears to be dominant. The Coconino Sandstone is prominent near Jacks, Leonard, and East Clear Creek Canyons.

Verde Limestone occurs in a small area in the westernmost part of the survey area. The lower elevations in the Verde Valley are largely old alluvium and recent alluvium from mixed sources.

The sedimentary rock in the survey area was deposited

on ancient sea floors during the Paleozoic Era. This era ranges in approximate age from 220 million years (Permian Period) to 470 million years (Cambrian Period). The basalt and other volcanic material and the alluvial material formed during the Cenozoic Era. This era ranges in approximate age from the present (Quaternary Period) to 60 million years (early Tertiary Period). The basalt and other volcanic material are largely of Tertiary age, and the alluvial material is of Quaternary age. The older alluvial material is approximately 10,000 to 35,000 years old, and the recent alluvial material is from the present to 10,000 years. There is no evidence of major geologic activity in the Area during the Mesozoic Era, which is the 160 million years between the Cenozoic and Paleozoic Eras.

Figure 2, a sketch map of the Area, shows the location and extent of the various rock types.

Climate ²

The terrain in the Long Valley Area has a pronounced effect on the local weather. The Mogollon Rim, the southern border of the Area and the major feature of the terrain, modifies air masses moving into the Area from the south. As southerly winds move upslope over the Rim, the air is cooled by expansion. Clouds that frequently form in this ascending current are often a source of precipitation. Thus, the area just north of the crest of the Rim has a mean annual precipitation of 30 to 35 inches, one of the highest in the State.

Few long-term climatological records are available for the Long Valley Area. Data on temperature and precipitation from four weather stations are shown in table 1. Three of these stations are outside the Area, but are fairly representative in climate and terrain at the specified elevations.

About one-third of the mean annual precipitation falls during July and August. During these 2 months and part of September, warm moist air from the Gulf of Mexico brings afternoon cloudiness and frequent thunderstorm activity. Shower activity usually reaches a peak about 5 p.m. in summertime. During July and August, rainfall measures 0.10 inch or more on about 10 days near the Mogollon Rim, and on about 8 days near the northern border of the Area. Summer thunderstorms can be locally intense and are accompanied by hail and by wind gusts of 50 to 75 miles per hour. Heavy rainfall in a short period usually occurs at this season. Records show, about once every hundred years, as much as 2.75 inches of precipitation in 1 hour and as much as 4 inches in 3 hours. The average maximum temperature in summertime reaches the high 80's at elevations near 5,000 feet and the low 80's near 7,000 feet. A temperature of 100° F. is seldom experienced in the Long Valley Area.

Moisture from the Pacific Ocean is a source of maximum precipitation in winter. Much of this precipitation falls as snow. During heavy storms, snow cover along the Mogollon Rim is 3 to 4 feet deep. Whereas maximum

² By PAUL C. KANGIESER, State climatologist, U.S. Department of Commerce, Environmental Sciences Services, Arizona State University, Tempe, Ariz.

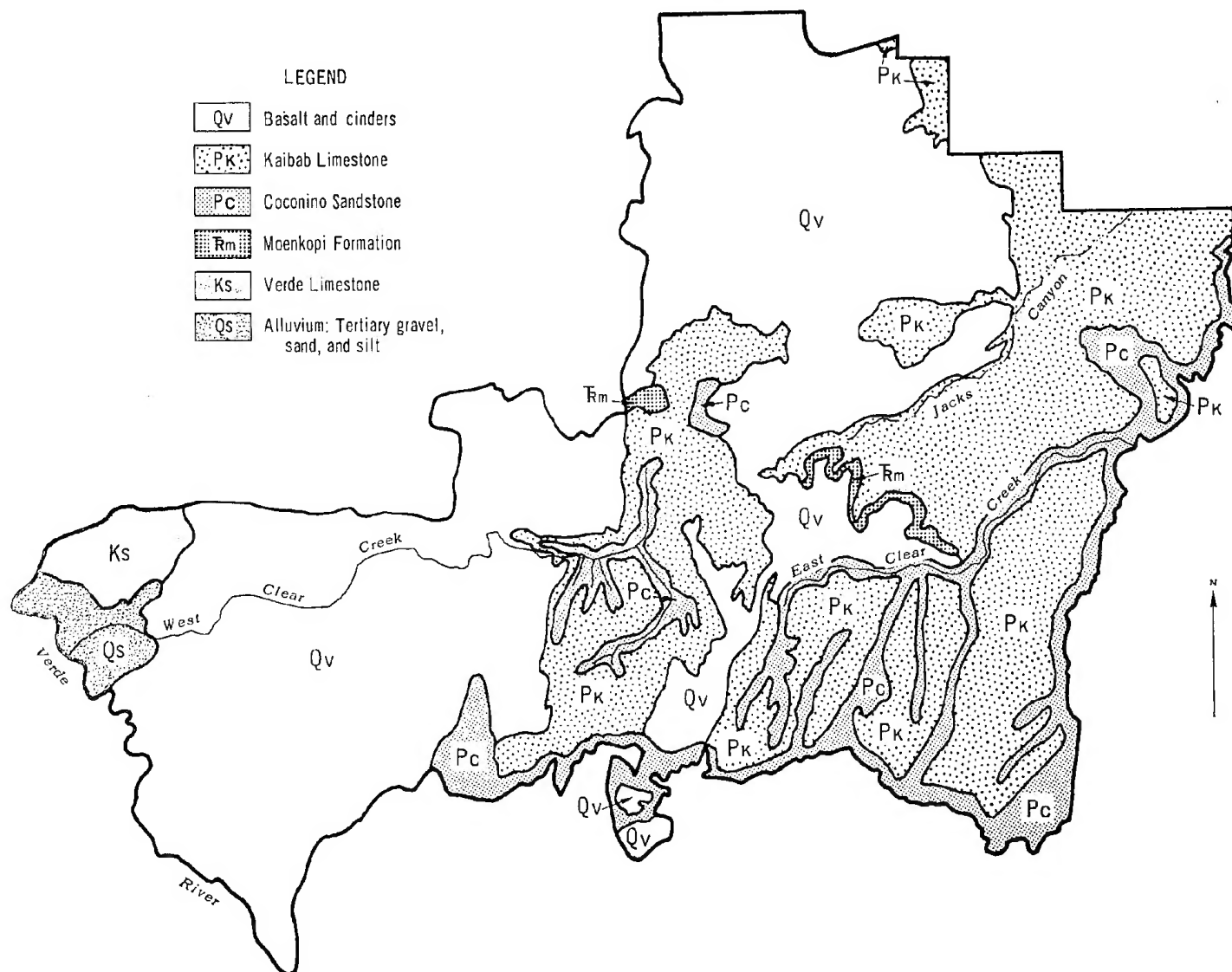


Figure 2.—Rock types in the Long Valley Area.

precipitation in a period of a few hours usually occurs in summer, the heaviest rainfall in a 24-hour period frequently occurs in winter. About once in a hundred years, 6 inches of precipitation in 24 hours is recorded along the Mogollon Rim and 5 inches in the northern part of the Area. The mean daily minimum temperature is in the low 20's at elevations of 5,000 feet and in the middle teens near 7,000 feet. A temperature of 25° below zero is recorded at the 7,000-foot level about once every 25 years.

Spring is a transitional period of decreasing precipitation and rising temperature. The last significant snowfall at the 7,000-foot level is usually before April 15; light falls, however, have been recorded early in May. May and June are typically dry, and the fire hazard increases until the rainy season begins late in June or early in July. The average date of the last 32° or lower

temperature is about May 15 at elevations of 5,000 feet and June 1 at 7,000 feet.

Another season of low precipitation is typical after the summer thunderstorm season and before the onset of Pacific storms late in November and early in December. The first significant snowfall at the 7,000-foot level is usually after the middle of November; light falls, however, have occurred near the end of October. The average date of the first 32° temperature in fall is usually about October 15 at elevations of 5,000 feet and about October 1 at 7,000 feet.

The mean annual lake evaporation in the Long Valley Area is approximately 55 inches. Wind data are not available, but mean monthly windspeeds probably reach a maximum of about 10 to 12 miles per hour late in spring and a minimum of about 6 to 8 miles per hour in fall.

SOIL SURVEY

TABLE 1.—*Temperature and precipitation*

Chevelon Ranger Station, Ariz. (Elevation 7,006 feet)

[Period of record: Temperature, 1939-65; precipitation, 1947-65]

Month	Temperature				Precipitation		
	Average daily maximum	Average daily minimum	Two years in 10 will have about 4 days with—		Average total	One year in 10 will have—	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or less than—		Less than—	More than—
	°F.	°F.	°F.	°F.	In.	In.	In.
January.....	44	17	57	—1	1.7	0.2	4.7
February.....	47	20	59	4	1.3	.3	2.8
March.....	51	23	63	11	1.3	.1	2.9
April.....	61	30	73	21	.8	.1	2.2
May.....	70	37	81	26	.4	(¹)	1.1
June.....	80	45	90	34	.5	0	1.6
July.....	83	53	91	45	2.9	1.3	4.8
August.....	80	52	87	44	3.5	1.4	5.6
September.....	76	45	85	35	1.7	(¹)	2.8
October.....	65	35	76	24	1.5	0	3.8
November.....	53	24	65	9	1.3	.1	3.0
December.....	46	19	59	5	1.6	.1	4.5
Year.....	63	33	² 93	³ —8	18.5	12.0	23.2

Fossil Springs, Ariz. (Elevation 4,269 feet)

[Period of record: 1936-65]

January.....	--	--	--	--	2.2	0.4	4.4
February.....	--	--	--	--	2.0	.3	4.2
March.....	--	--	--	--	2.2	.1	4.8
April.....	--	--	--	--	1.2	(¹)	3.1
May.....	--	--	--	--	.5	0	1.2
June.....	--	--	--	--	.5	0	1.1
July.....	--	--	--	--	2.5	.7	6.2
August.....	--	--	--	--	3.1	.8	7.2
September.....	--	--	--	--	1.7	(¹)	2.9
October.....	--	--	--	--	1.4	0	4.1
November.....	--	--	--	--	1.4	0	3.1
December.....	--	--	--	--	2.3	.3	6.3
Year.....	--	--	--	--	21.0	13.8	31.5

Mormon Lake Ranger Station, Ariz. (Elevation 7,180 feet)

[Period of record: Temperature, 1948-65; precipitation, 1939-65]

January.....	--	--	--	--	--	--	--
February.....	--	--	--	--	--	--	--
March.....	--	--	--	--	--	--	--
April.....	--	--	--	--	--	--	--
May.....	66	34	78	25	.6	(¹)	1.7
June.....	77	42	87	32	.7	0	3.2
July.....	81	50	89	44	2.2	.6	3.4
August.....	78	49	85	41	3.2	.7	5.4
September.....	73	42	82	32	2.1	.2	4.3
October.....	64	32	75	22	1.7	(¹)	4.2
November.....	--	--	--	--	--	--	--
December.....	--	--	--	--	--	--	--
Year.....	--	--	² 90	--	--	--	--

See footnotes at end of table.

TABLE 1.—*Temperature and precipitation—Continued*

Payson 12 NNE, Ariz. (Elevation 5,500 feet)

[Period of record: Temperature, 1957–65; precipitation, 1953–65]

Month	Temperature				Precipitation		
	Average daily maximum	Average daily minimum	Two years in 10 will have about 4 days with—		Average total	One year in 10 will have—	
			Maximum temperature equal to or higher than—	Minimum temperature equal to or less than—		Less than—	More than—
	°F.	°F.	°F.	°F.	In.	In.	In.
January.....	51	21	63	7	3.0	0.5	9.9
February.....	53	22	67	12	2.2	.1	4.4
March.....	56	25	69	16	2.3	(1)	6.5
April.....	66	30	79	23	1.4	.3	3.8
May.....	74	35	85	27	.6	(1)	2.3
June.....	84	43	93	34	.9	(1)	3.0
July.....	88	53	95	46	3.4	.5	6.3
August.....	84	53	92	47	4.9	1.2	8.9
September.....	79	46	87	36	2.0	(1)	5.5
October.....	72	37	83	29	1.9	.2	5.4
November.....	59	28	71	18	1.9	.1	5.3
December.....	54	24	65	15	2.8	.2	9.8
Year.....	68	35	² 97	³ 0	27.3	22.7	43.2

¹ Trace.² Average annual maximum temperature.³ Average annual minimum temperature.

Vegetation

Variations in elevation, climate, aspect, and soil influence the vegetation in the Long Valley Area. Three types of cover are recognized; the ponderosa pine type, which consists of forest and open parks; the pinyon-juniper type, which consists of forest and open grassland; and the grassland-desert shrub type. Each type is associated with particular soils and with a particular range in altitude and amount of rainfall. The approximate location and extent of the three cover types are shown in figure 3.

The ponderosa pine forest type is at the higher elevations, on the Coconino Plateau. The average annual precipitation is 18 inches or more. The soils are the Broliar, Hogg, McVickers, Siesta, Soldier, and Sponseller. Much of this forest has had a partial cut for saw logs. The overstory is chiefly ponderosa pine, and the understory is bunchgrass. Limber pine, Douglas-fir, and white fir grow in the deep canyons at the higher elevations. Much of this area also has a generous cover of Gambel oak, alligator juniper, and pinyon pine. New Mexico locust occurs in several areas, generally on north aspects, and aspen grows on some of the more moist sites. The chief grass species are Arizona fescue, mountain muhly, pine dropseed, squirreltail, and blue grama. The open parks, which are Friana and Luth soils, support western wheatgrass and blue grama.

The pinyon-juniper forest type is at elevations below the ponderosa pine, dominantly on the lower part of the Coconino Plateau, just above the Mogollon Rim and in fringe areas in the northern and eastern parts of the survey area. It also occurs at the higher elevations below

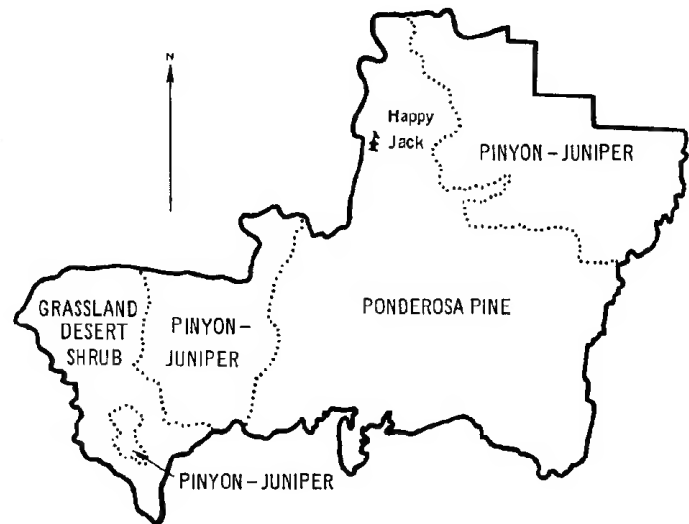


Figure 3.—Vegetation in the Long Valley Area.

the Rim. Annual precipitation is about 15 inches. Cabezon, Gem, and Springerville are the dominant soils. The overstory is predominantly juniper, chiefly the Utah and alligator species. The most common grasses in the understory are blue grama, hairy grama, side-oats grama, squirreltail, stipa, and some little bluestem. Large areas are open grassland, principally blue grama, western wheatgrass, three-awn, and squirreltail; some shrubs, such as buckwheat, snakeweed, and rabbitbrush; and scattered pinyon pine and juniper trees.

The grassland-desert shrub type of vegetation is below the Mogollon Rim. Annual precipitation is about 10 to 12 inches. Anthony, Bridge, Graham, Guest, House Mountain, and Retriever are the principal soils. A large part of this area supports only sparse vegetation, and much of the surface area is barren. In some areas are dense stands of semidesert species, and in others distinct patterns of vegetation, such as grasses, shrubs, and scattered pinyon pine and juniper. The pattern is commonly a shrub overstory and a grass understory. The chief shrubs are creosotebush, mesquite, canotia, catclaw, pricklypear, and snakeweed. Grasses are sand dropseed, three-awn, galleta, blue grama, and tobosa. Filaree, a common annual forb, grows abundantly if the moisture supply is adequate.

Wildlife

The ponderosa pine, pinyon-juniper, and grassland-desert shrub vegetative types in the Long Valley Area provide a favorable environment for a variety of wildlife. The principal game animals in the Area are mule deer, white-tailed deer, elk, antelope, bear, squirrel, cottontail rabbit, and javelina. Game birds are turkey, Gambel's quail, and western mourning dove. Rainbow trout are abundant in streams and lakes, and channel catfish in the Verde River. A rare species of minnow, the Little Colorado spinedace, can be found in East Clear Creek.

Mule deer, the most common big game animal in the Area, migrate between the ponderosa pine forest and the pinyon-juniper woodland as the seasons change. Antelope and wild turkey also inhabit these areas. Elk have been reintroduced to the region and are hunted on a limited harvest basis. White-tailed deer and javelina graze chiefly on the grassland-desert shrub type of vegetation. Gambel's quail and western mourning dove inhabit the grassland-desert shrub areas.

Predators and nongame animals are fox, skunk, mountain lion, bobcat, coyote, porcupine, and many other smaller forest creatures. Waterfowl, such as geese, mallard, and teal, are occasionally on lakes and streams in small numbers.

Fishing waters in the Area are Blue Ridge Reservoir, Knoll Lake, Soldier Lake, Soldier Annex Lake, Barber-shop Canyon, West Clear Creek, Verde River, and the lower reaches of East Clear Creek. The Verde River provides warm-water fishing, and the rest provide trout fishing.

People and Their Use of the Land

The Long Valley Area became part of the Coconino National Forest in 1908. It was once part of the San Francisco Mountains and Black Mesa Forest Reserves. These lands were reserved from the public domain by Presidential proclamation in 1898.

The Long Valley Area is important to the economy of Arizona. It is managed by the Forest Service, under multiple-use and sustained-yield principles, and is used for timber, wildlife, livestock, and watershed.

Logging of the virgin ponderosa pine forest started about 1945, but no large amount of timber was removed until the early 1950's. The present annual, allowable cut

is about 40 million board feet, or enough lumber to build 2,700 five-room houses. The timber is trucked to Flagstaff for processing.

The Area provides range for wildlife and cattle; livestock have grazed on it since before the turn of the century. At present, cattle are grazed on a seasonal basis. The lower elevations are grazed in winter and spring, and the higher elevations in summer and fall. Ranchers depend heavily on the forage provided by this range.

Water, a valuable product of this Area, is used locally for livestock and recreation. Water flowing from West Clear Creek and Fossil Creek into the Verde River is needed in the Salt River Valley for irrigation and for domestic and industrial uses. Likewise, the runoff through East Clear Creek, Leonard Canyon, and Jacks Canyon adds to the water resource of the Little Colorado River Basin.

The Long Valley Area is thinly populated. The population is concentrated in the Verde Valley. During the logging season, about 350 people live within the forested area of the plateau country. Several ranches maintain summer headquarters in the high country.

Part II: The Soils

This section describes the soil series and mapping units in the Long Valley Area. Each soil series is described in considerable detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Unless it is otherwise stated, the colors given in the descriptions are those of a dry soil.

Not all mapping units are of a soil series. Limestone and sandstone rock land, for example, does not belong to a soil series, but nevertheless, is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability subclass, the range groups, and the recreation group to which the mapping unit has been assigned. The designations for the capability subclass and the timber, range, and recreation groups are listed in the "Guide to Mapping Units" at the back of this survey.

Figures 4 and 5 show typical patterns of soils in various parts of the areas.

The approximate acreage and proportionate extent

of each mapping unit are shown in table 2. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (7).

Anthony Series

The Anthony series consists of well-drained soils that formed in material deposited by streams and washes. These soils are on flood plains and low terraces. The slope gradient is no more than 2 percent. The elevation ranges from 3,300 to 3,500 feet. Annual rainfall is 11 to 13 inches, the average annual temperature is 62° F., and the frost-free period is about 230 days. The vegetation is mesquite, creosotebush, annual weeds, and grasses. These soils are associated with Cornville, Hantz, and Cowan soils.

In a representative profile the surface layer is pinkish-gray fine sandy loam about 12 inches thick. The underlying layers are brown to light-brown sandy loam. The profile is calcareous throughout.

Permeability is moderately rapid. The available water capacity is 6½ to 7½ inches in the 60 inches or more of effective rooting depth.

Anthony soils are used mostly for range and irrigated pasture.

Representative profile of Anthony fine sandy loam, 0 to 2 percent slopes, in an irrigated pasture, SE¼NE¼ sec. 21, T. 13 N., R. 5 E., Yavapai County:

Ap—0 to 12 inches, pinkish-gray (7.5YR 6/2) fine sandy loam, brown (7.5YR 4/2) moist; weak, medium, granular structure; soft, friable, nonsticky and nonplastic; common very fine roots; common very fine tubular pores; strongly effervescent; moderately alkaline (pH 8.2); gradual, wavy boundary.

C1—12 to 45 inches, brown (7.5YR 5/4) sandy loam, brown (7.5YR 4/4) moist; massive; slightly hard, friable, nonsticky and slightly plastic; common very fine roots; common very fine tubular pores; strongly effervescent; moderately alkaline (pH 8.4); gradual, wavy boundary.

C2—45 to 72 inches, light-brown (7.5YR 6/4) sandy loam, yellowish red (5YR 4/6) moist; massive; slightly hard, friable, nonsticky and nonplastic; very few fine roots; few very fine tubular pores; strongly effervescent; moderately alkaline (pH 8.4).

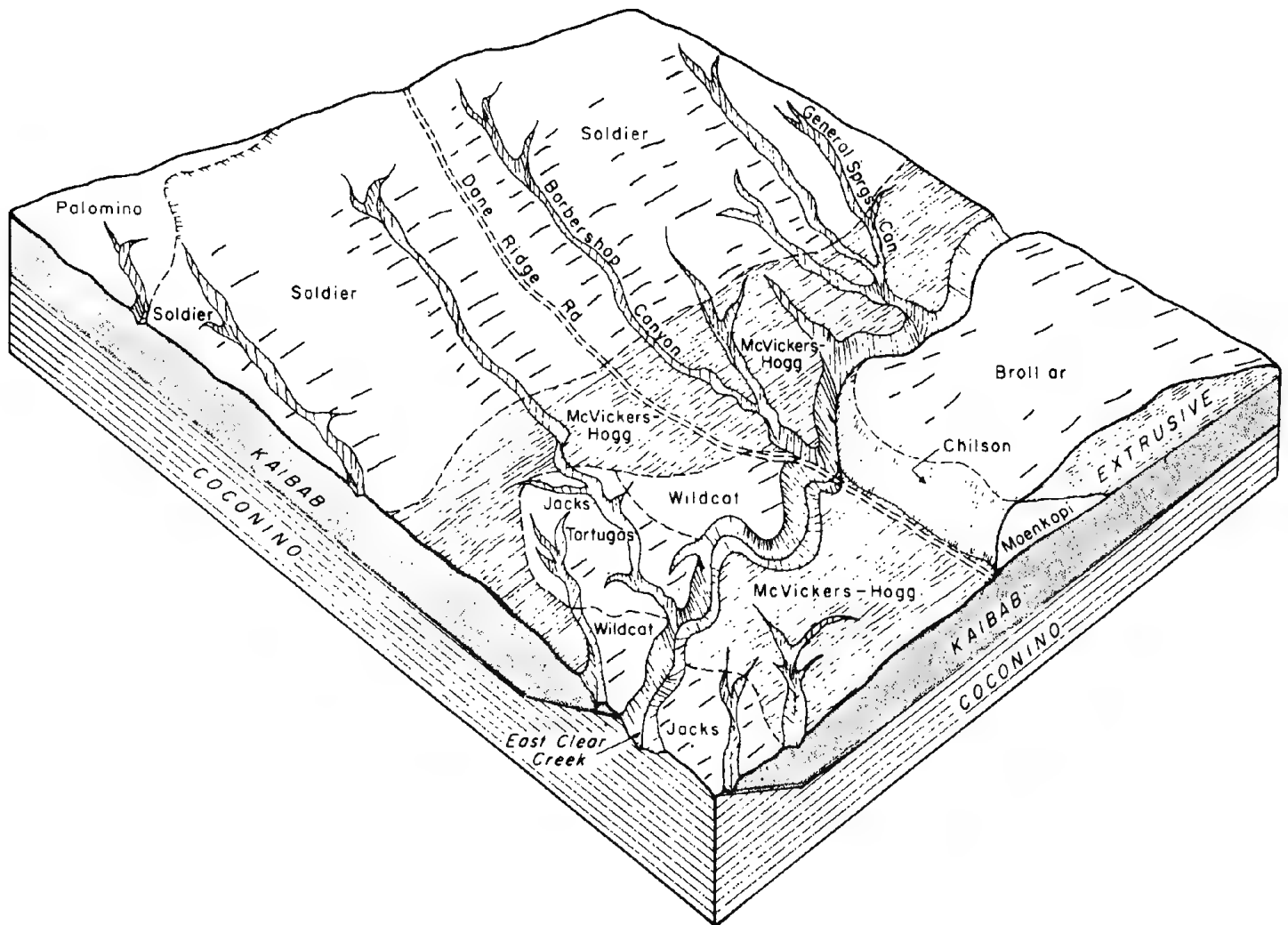


Figure 4.—Typical pattern of soils in area south of East Clear Creek.

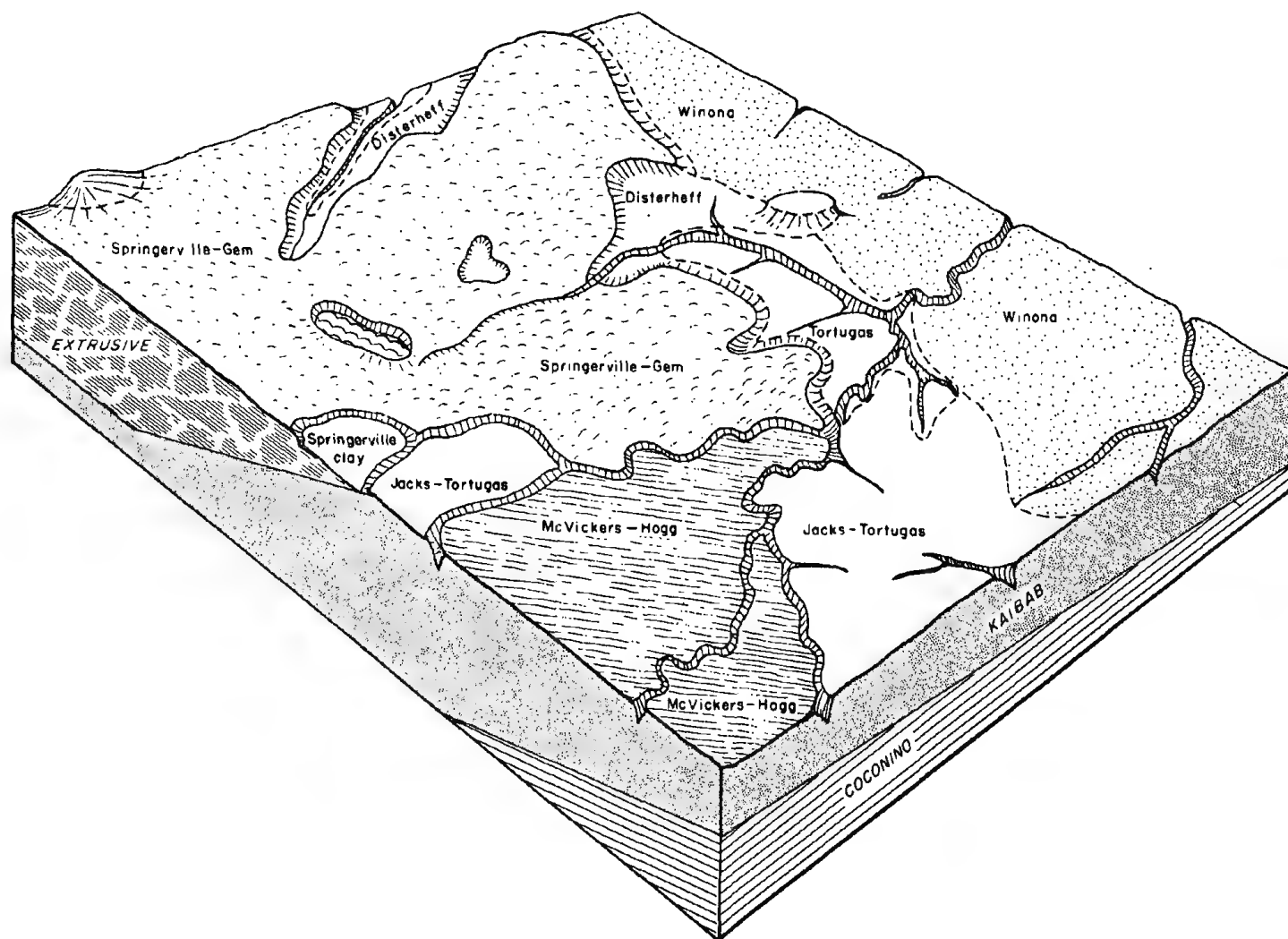


Figure 5.—Typical pattern of soils in area north of East Clear Creek.

The A horizon in most places is fine sandy loam or sandy loam, but in some it is loam or silt loam. The A and C horizons are dominantly of 7.5YR hue, but range from 5YR to 10YR; value is 5 to 7 dry or 4 moist, and chroma is 2 to 4 dry or 2 to 6 moist. The C horizon ranges from coarse sandy loam to fine sandy loam. In places the profile is as much as 20 percent gravel.

Anthony fine sandy loam, 0 to 2 percent slopes (AnA).—

This soil is on terraces and benches along West Clear Creek and the Verde River. The relief is smooth. Natural slopes are about 2 percent, but in leveled areas they are 1 percent or less.

Included with this soil in mapping are small areas of Guest and Cowan soils.

Runoff is slow. The erosion hazard is moderate.

This Anthony soil is in range herbage group 2, range improvement group 2, recreation group 1c, and capability subclasses IIs irrigated and VIs dryland.

Arizo Series

The Arizo series consists of excessively drained, highly stratified soils that formed in mixed alluvium on flood

plains and first bottoms of West Clear Creek and the Verde River. The surface is irregular. Slopes are 0 to 2 percent. Elevation ranges from 3,000 to 3,500 feet. Annual rainfall is 10 to 12 inches, the average annual temperature is 64° F., and the frost-free period is about 230 days. The vegetation is cottonwood, willow, mesquite, berbudagrass, and annual weeds.

In a representative profile the surface layer is brown, stratified sand and loamy sand. Below this is brownish fine gravelly sand and very gravelly and very cobbly sand that extend to a depth of 60 inches or more. The profile is calcareous throughout.

Permeability is very rapid. Available water capacity is $2\frac{1}{4}$ to $3\frac{1}{2}$ inches in the 60 inches or more of effective rooting depth.

Arizo soils are a source of sand and gravel, and they are used for recreation.

The Arizo soils in the Long Valley Area are mapped only with Cowan soils.

Representative profile of an Arizo soil in an area of Cowan and Arizo soils, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 21, T. 13 N., R. 5 E., Yavapai County:

A1—0 to 12 inches, brown (7.5YR 5/2) stratified sand and loamy sand, dark brown (7.5YR 4/2) moist; single grain; loose dry and moist; common very fine and fine roots; many very fine and fine interstitial pores; slightly effervescent; moderately alkaline (pH 8.4); abrupt, smooth boundary.

C1—12 to 18 inches, grayish-brown (10YR 5/2) fine gravelly sand, brown (10YR 5/3) moist; massive; slightly hard, friable; few fine roots; common fine and medium interstitial pores; 40 percent fine gravel; strongly effervescent; moderately alkaline (pH 8.4); abrupt, wavy boundary.

C2—18 to 72 inches, grayish-brown (10YR 5/2) very gravelly and very cobbly sand, brown (10YR 5/3) moist; loose dry and moist; few fine roots; common fine and medium interstitial pores; 80 percent coarse fragments predominantly cobblestones; fragments are carbonate coated and strongly to violently effervescent; moderately alkaline (pH 8.4).

The A horizon is fine sand, loamy sand, or gravelly sand. The profile is more than 50 percent coarse fragments. It ranges from noneffervescent to violently effervescent. It is of 7.5YR and 10YR hues.

Basalt Rock Land

Basalt rock land (Ba) is in the ponderosa pine and the pinyon-juniper forests where basalt flows are common. It is an area of steep to extremely steep hillsides having slopes of 20 to 80 percent; basalt escarpments, talus, rock outcrop, and pockets of shallow soil; and vertical or nearly vertical cliffs, many of which are impassable to horseback and vehicular travel. In areas where slopes are less than 40 percent and there are fewer rock outcrops, the surface is extremely stony and cobbly and the pockets of soil are shallow to very shallow over bedrock. Elevation ranges from 5,000 to 7,100 feet. Precipitation ranges from 11 to 24 inches, and the average annual temperature is 44° to 61° F. The frost-free period is 130 to 230 days.

Basalt rock land is associated with Brolliar, Cabezon, Disterheff, Gem, Graham, House Mountain, and Springerville soils.

TABLE 2.—Approximate acreage and proportionate extent of the soils

Soil	Area	Extent	Soil	Area	Extent
	<i>Acres</i>	<i>Percent</i>		<i>Acres</i>	<i>Percent</i>
Anthony fine sandy loam, 0 to 2 percent slopes...	660	0.1	Jacks-Tortugas extremely rocky complex, 20 to 45 percent slopes...	8,121	1.3
Basalt rock land.....	45,128	7.0	Limestone and sandstone rock land.....	42,480	6.8
Bridge gravelly sandy loam, 0 to 15 percent slopes.....	1,124	.2	Luth clay loam, 0 to 5 percent slopes.....	2,174	.3
Bridge cobbly loam, 10 to 30 percent slopes.....	1,593	.2	Lynx fine sandy loam, 0 to 5 percent slopes.....	600	.1
Brolliar clay loam, 0 to 5 percent slopes.....	5,112	.8	McVickers very fine sandy loam, 0 to 10 percent slopes.....	17,574	2.8
Brolliar very stony clay loam, 0 to 10 percent slopes.....	68,568	11.0	McVickers-Hogg complex, 0 to 10 percent slopes.....	7,808	1.3
Brolliar very stony clay loam, 10 to 30 percent slopes.....	20,432	3.3	McVickers-Hogg complex, 10 to 30 percent slopes.....	13,591	2.2
Cabezon cobbly clay loam, 20 to 60 percent slopes.....	10,372	1.7	Navajo silty clay, 0 to 5 percent slopes.....	810	.1
Cabezon very stony clay loam, 0 to 20 percent slopes.....	21,806	3.5	Overgaard sandy loam, 0 to 20 percent slopes.....	1,695	.3
Cabezon extremely rocky loam, 0 to 20 percent slopes.....	1,336	.2	Palomino very stony fine sandy loam, 0 to 15 percent slopes.....	4,532	.7
Chilson cobbly clay loam, 20 to 45 percent slopes.....	2,375	.4	Penthouse cobbly loam, 0 to 10 percent slopes.....	2,044	.3
Clover Springs silt loam, 0 to 5 percent slopes.....	1,970	.3	Retriever loam, 0 to 10 percent slopes.....	220	(¹)
Cornville fine sandy loam, 0 to 5 percent slopes.....	388	(¹)	Retriever very stony loam, 0 to 30 percent slopes.....	10,011	1.6
Cowan and Arizo soils.....	899	.1	Rimrock cobbly clay, 0 to 10 percent slopes.....	3,391	.5
Disterheff very stony clay loam, 20 to 45 percent slopes.....	5,181	.8	Sanchez extremely stony sandy loam, 0 to 15 percent slopes.....	3,232	.5
Dye fine sandy loam, 0 to 10 percent slopes.....	3,418	.5	Siesta loam, 0 to 5 percent slopes.....	1,214	.2
Dye very stony fine sandy loam, 0 to 20 percent slopes.....	1,272	.2	Siesta cobbly loam, 0 to 20 percent slopes.....	6,460	1.0
Friana clay loam, 0 to 2 percent slopes.....	1,138	.2	Soldier cobbly loam, 0 to 10 percent slopes.....	29,973	4.8
Gem cobbly clay loam, 0 to 20 percent slopes.....	35,580	5.7	Soldier cobbly loam, 20 to 45 percent slopes.....	31,431	5.0
Glendale gravelly fine sandy loam, 0 to 10 percent slopes.....	738	.1	Soldier-McVickers very rocky complex, 20 to 60 percent slopes.....	2,649	.4
Glendale gravelly silt loam, 0 to 5 percent slopes.....	1,019	.2	Sponseller gravelly silt loam, 10 to 40 percent slopes.....	2,274	.4
Graham and House Mountain soils, 0 to 30 percent slopes.....	10,715	1.7	Springerville clay, 0 to 10 percent slopes.....	11,419	1.8
Graham and House Mountain soils, 30 to 60 percent slopes.....	7,537	1.2	Springerville cobbly clay, 0 to 10 percent slopes.....	43,067	6.9
Guest clay, 0 to 5 percent slopes.....	225	(¹)	Springerville-Gem complex, 0 to 20 percent slopes.....	27,182	4.6
Hantz gravelly silty clay, 0 to 5 percent slopes.....	482	.1	Stony rough land, ash and tuff.....	21,471	3.5
Hogg fine sandy loam, 0 to 20 percent slopes.....	14,713	2.4	Tortugas very stony loam, 0 to 30 percent slopes.....	19,637	3.1
Hogg loam, calcareous variant, 0 to 10 percent slopes.....	478	.1	Waldroup gravelly silty clay loam, 5 to 30 percent slopes.....	4,220	.7
House Mountain stony loam, 0 to 30 percent slopes.....	3,643	.6	Wildcat gravelly fine sandy loam, 0 to 5 percent slopes.....	4,506	.7
Jacks fine sandy loam, 0 to 20 percent slopes.....	6,070	1.0	Wildcat very rocky loam, 0 to 20 percent slopes.....	7,180	1.1
Jacks-Tortugas extremely rocky complex, 0 to 20 percent slopes.....	7,037	1.1	Winona gravelly loam, 0 to 10 percent slopes.....	14,648	2.3
			Total.....	626,623	100.0

¹ Less than 0.1 percent.

At the higher elevations, under pine forest, Basalt rock land is about 40 to 50 percent soil material and 50 to 60 percent boulders and rock outcrop. The pockets of soil are about 20 to 30 inches deep, and the soil resembles Broliar soils.

At the lower elevations, Basalt rock land is 20 to 25 percent pockets of a shallow to very shallow soil that resembles Cabezon soils.

Vegetation is sparse at the higher elevations. It consists of poorly formed ponderosa pine and of Gambel oak, New Mexico locust, Arizona fescue, and junegrass. At the lower elevations, the vegetation is pinyon pine, juniper, gramagrass, and cactus.

Permeability is very slow to moderate. Runoff is medium to very rapid, and the erosion hazard is high.

Basalt rock land provides escape and concealment for wildlife and has value for water yield from surface runoff. Only the less sloping areas can be used for grazing.

Basalt rock land is in range herbage group 5, range improvement group 3, recreation group 5b, and capability subclass VIIIs dryland.

Bridge Series

The Bridge series consists of nearly level to moderately steep, well-drained soils that are 22 to 40 inches deep. These soils formed in alluvium, volcanic ash, and tuff on old terraces, benches, and fans. Slopes are 0 to 30 percent. Elevation ranges from 3,000 to 4,000 feet. Annual rainfall is 10 to 13 inches, the average annual temperature is 60° to 64° F., and the frost-free period is 200 to 230 days. The vegetation is canotia, pricklypear, juniper, algerita, yucca, blackbrush, Arizona cottontop, side-oats grama, fluffgrass, and three-awn. These soils are associated with House Mountain, Retriever, and Rimrock soils.

In a representative profile the surface layer is grayish-brown cobbly loam about 6 inches thick. About 20 percent of the surface area is covered with gravel and cobblestones. The underlying layer is pinkish-gray or brown sandy clay loam and gravelly sandy loam 18 inches deep over tuff and volcanic ash. The profile is calcareous throughout.

Permeability is moderate. The available water capacity is 4 to 6½ inches in the 22 to 36 inches of effective rooting depth.

Bridge soils are used as winter range for livestock and big game.

Representative profile of Bridge cobbly loam, 10 to 30 percent slopes, under native range cover, SE¼ sec. 20, T. 14 N., R. 6 E., Yavapai County:

A1—0 to 6 inches, grayish-brown (10YR 5/2) cobbly loam, brown (10YR 4/3) moist; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; few very fine and fine roots; common micro and very fine interstitial pores; 20 percent cobblestones and 20 percent gravel; strongly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C1—6 to 17 inches, pinkish-gray (7.5YR 6/2) gravelly light sandy clay loam, brown (7.5YR 5/4) moist; massive; slightly hard, friable, sticky and plastic; few very fine, fine, medium, and coarse roots; common micro and very fine interstitial pores; 15 percent gravel;

violently effervescent; moderately alkaline (pH 8.4); gradual, wavy boundary.

C2ca—17 to 24 inches, pinkish-gray (7.5YR 6/2) gravelly heavy sandy loam, brown (7.5YR 5/4) moist; massive; hard, firm, slightly sticky and slightly plastic; few very fine and fine roots; few very fine interstitial pores; 20 percent gravel; violently effervescent; moderately alkaline (pH 8.4); clear, wavy boundary.

C3—24 inches, pinkish-gray (7.5YR 7/2) tuff and ash, brown (7.5YR 5/4) moist; hard dry or moist; effervescent; moderately alkaline (pH 8.4).

The A horizon is commonly cobbly loam, but ranges from gravelly loam to gravelly sandy loam. The C horizon is gravelly sandy clay loam, gravelly light clay loam, or gravelly heavy sandy loam. Color value is 3 to 4 for both horizons. This soil is gravelly and cobbly throughout, but the C1 and C2 horizons are typically less than 35 percent coarse fragments. For the most part, these soils are calcareous throughout, but in some areas they are calcareous only in the lower part of the profile.

Bridge gravelly sandy loam, 0 to 15 percent slopes (BdC).—This soil has a profile similar to the one described as representative of the Bridge series, but its surface layer differs in texture and there are fewer cobblestones and pebbles on the surface.

Included with this soil in mapping are small areas where the soil is less than 20 inches deep over ash and tuff.

Runoff is slow, and the erosion hazard is moderate.

This soil is in range herbage group 4, range improvement group 3, recreation group 3a, and capability subclass VIc dryland.

Bridge cobbly loam, 10 to 30 percent slopes (BeD).—This soil formed in old alluvium. It has the profile described as representative of the Bridge series.

Included with this soil in mapping are small areas of similar soils that are less than 20 inches deep over ash and tuff and some small areas of Rimrock soils.

About 50 percent of the acreage is barren. The erosion hazard is moderate.

This Bridge soil is in range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIs dryland.

Broliar Series

The Broliar series consists of nearly level to moderately steep, well-drained soils that are 24 to 60 inches deep over bedrock. These soils formed in residuum weathered from basalt. They are on uplands. Slopes range from 0 to 30 percent. The elevation ranges from 6,700 to 7,400 feet. Annual rainfall is 18 to 22 inches, the average annual temperature is 44° to 46° F., and the frost-free period is 90 to 100 days. The vegetation is chiefly ponderosa pine, Gambel oak, alligator juniper, pinyon pine, Arizona fescue, pine dropseed, squirreltail, and junegrass. These soils are associated with the Cabezon, Siesta, and Sponseller soils on uplands, and with Friana and Luth soils in open parks and on drainage bottoms.

In a representative profile a ½- to 1-inch layer of undecomposed and partially decomposed pine needles overlies the mineral soil. About 20 to 40 percent of the surface area is covered with stones and cobblestones. The surface layer is about 3 inches of clay loam. The subsoil

is brown and dark-brown cobbly clay. Basalt bedrock is at a depth of 24 inches. The profile is noncalcareous throughout.

Permeability is slow.

Brolliar soils are used for timber, watershed, and wildlife, and for summer grazing of livestock.

Representative profile of Brolliar very stony clay loam, 0 to 10 percent slopes, in an area of ponderosa pine, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 23, T. 14 N., R. 10 E., Coconino County:

O1— $\frac{1}{2}$ inch to 0, discontinuous layer of pine needle litter; neutral (pH 7.2).

A1—0 to 3 inches, brown (10YR 5/3) very stony clay loam, dark brown (10YR 3/3) moist; moderate, medium and coarse, granular structure; slightly hard, friable, sticky and slightly plastic; common very fine and fine roots; many micro and very fine interstitial pores; about 15 percent stones and 5 percent gravel and cobblestones; mildly alkaline (pH 7.4); clear, smooth boundary.

B1—3 to 6 inches, dark grayish-brown (10YR 4/2) light clay, very dark grayish brown (10YR 3/2) moist; weak, fine, subangular blocky structure; hard, firm, sticky and plastic; few very fine and fine roots; common micro and very fine interstitial pores and very fine tubular pores; about 10 percent cobblestones and 5 percent gravel; mildly alkaline (pH 7.6); clear, smooth boundary.

B21t—6 to 11 inches, brown (7.5YR 4/2) cobbly clay, dark brown (7.5YR 3/2) moist; moderate, fine and medium, subangular blocky structure; very hard, very firm, sticky and very plastic; few very fine and fine roots and common medium and coarse roots; common micro and very fine interstitial pores; about 10 percent gravel and 15 percent cobblestones; mildly alkaline (pH 7.6); clear, smooth boundary.

B22t—11 to 24 inches, dark-brown (10YR 3/3) cobbly heavy clay, dark brown (10YR 3/3) moist; moderate, coarse, subangular blocky structure; very hard, extremely firm, sticky and very plastic; few fine, medium, and coarse roots; few micro and very fine interstitial pores; 10 percent stones and 30 percent cobblestones; common pressure faces and few small slickensides; mildly alkaline (pH 7.8); abrupt, irregular boundary.

R—24 inches, basalt rock; some fractures filled with material from B22t horizon.

The A horizon is very stony clay loam, very stony loam, or clay loam. It is of 7.5YR or 10YR hue; value is 3 to 5 dry and 2 or 3 moist, and chroma is 2 or 3. The B horizon is cobbly clay or cobbly heavy clay loam. It is of 5YR to 10YR hue; value is 3 to 5 dry, and chroma is 2 or 3. Stones and cobblestones cover 30 to 50 percent of the surface area.

Brolliar clay loam, 0 to 5 percent slopes (B1B).—This soil is on uplands and colluvial material at elevations of 6,700 to 7,100 feet. It is deeper and less stony, but otherwise it has a profile similar to the one described as representative of the series. The depth to bedrock ranges from 40 to 60 inches. No more than 5 to 10 percent of the surface area is covered with stones.

About 5 percent of the acreage of this soil is a Brolliar very stony clay loam.

Runoff is slow, and the erosion hazard is slight. The available water capacity is 6 to 8 inches in the 40 to 60 inches of effective rooting depth.

This Brolliar soil produces timber and range herbage, and it supplies good summer range. It is in timber group 2a, range herbage group 2, range improvement group 2, recreation group 2a, and capability subclass VIs dryland.

Brolliar very stony clay loam, 0 to 10 percent slopes (BrC).—This soil is on uplands. It has the profile described

as representative of the series. The surface area is 15 to 25 percent stones. The slope ranges from 0 to 10 percent, but is dominantly 4 to 6 percent.

Included with this soil in mapping are small areas of Siesta soils, mostly adjacent to cinder deposits; areas of Friana and Luth soils in the small drainageways; and areas of Cabezon soils in the stonier parts of the unit. Inclusions amount to about 5 percent of each mapped area.

Runoff is slow, and the erosion hazard is slight to moderate. The available water capacity is 3 to 6 inches in the 24 to 40 inches of effective rooting depth.

This Brolliar soil is used chiefly for timber (fig. 6), herbage, wildlife, and water yield. It is in timber group 2b, range herbage group 3, range improvement group 3, recreation group 2a, and capability subclass VIs dryland.

Brolliar very stony clay loam, 10 to 30 percent slopes (BrD).—This soil is stonier and steeper and consequently has a thinner profile than the profile described as representative of the series. The surface area is typically 20 to 30 percent stones.

Included with this soil in mapping are areas of Cabezon soils and a few small areas of Siesta soils. Inclusions make up 10 to 15 percent of the acreage.

Runoff is medium. The erosion hazard is high. Any soil or plant disturbance increases the erosion hazard.

This Brolliar soil is used mainly for timber, herbage, wildlife, and water yield. It is timber group 3, range herbage group 3, range improvement group 3, recreation group 2b, and capability subclass VIs dryland.

Cabezón Series

The Cabezon series consists of nearly level to very steep, well-drained soils that are only 8 to 20 inches deep over basalt. These soils formed in residuum derived from basalt. They are on uplands and in the mountains. Slopes range from 0 to 60 percent. Elevation ranges from 4,200 to 7,000 feet. Annual rainfall is 12 to 20 inches, the average annual temperature is 48° to 58° F., and the frost-free period is 150 to 230 days. The vegetation is alligator and Utah juniper, blue grama, squirreltail, pine dropseed, side-oats grama, and junegrass. There are stands of poorly formed ponderosa pine at the high elevations. These soils are associated with Brolliar, Gem, Graham, House Mountain, and Springville soils.

In a representative profile the surface layer is brown very stony clay loam about 3 inches thick. The subsoil is reddish-brown clay. Hard, dense basalt is at a depth of 17 inches. The soil is typically noncalcareous throughout, but in places the subsoil is calcareous just above the bedrock.

Permeability is slow. The available water capacity is 2 to 4 inches in the 8 to 20 inches of effective rooting depth.

Cabezón soils provide range for livestock and wildlife and a source of water for areas at lower elevations.

Representative profile of Cabezon very stony clay loam, 0 to 20 percent slopes, in an area of native rangeland, NW $\frac{1}{4}$ sec. 13, T. 15 N., R. 10 E., Coconino County:

A1—0 to 3 inches, brown (10YR 5/3) very stony clay loam, dark brown (10YR 3/3) moist; strong, fine, granular structure; soft, very friable, sticky and slightly plas-



Figure 6.—Tree and grass cover on Brolliar very stony clay loam.

tic; many very fine and fine roots; many micro and very fine interstitial pores; 25 percent stones, 20 percent pebbles and cobblestones; neutral (pH 7.0); clear, smooth boundary.

B21t—3 to 9 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) moist; moderate, medium, subangular blocky structure; hard, firm, sticky and very plastic; common very fine and fine roots; common very fine tubular and interstitial pores; few moderately thick clay films on ped faces; 5 percent cobblestones; mildly alkaline (pH 7.4); clear, wavy boundary.

B22t—9 to 17 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) moist; moderate, medium and coarse, subangular and angular blocky structure; very hard, very firm, sticky and very plastic; few very fine and fine roots; common very fine tubular and interstitial pores; common moderately thick clay films on ped faces; 5 percent stones; mildly alkaline (pH 7.4); abrupt, wavy boundary.

R—17 inches, hard, dense basalt.

The A horizon is very stony clay loam, loam, or cobbly clay loam. It is of 7.5YR to 10YR hue; value is 4 or 5 dry and 3 to 4 moist, and chroma ranges from 2 to 4. The B horizon is clay or heavy clay loam. It is dominantly of 5YR hue, but ranges from 10YR to 2.5YR. Coarse fragments on the surface are 10 to 30 percent stones, 5 to 15 percent cobblestones, and 10 to 20 percent pebbles. The depth to basalt is typically 14 to 18 inches, but ranges from 8 to 20 inches.

Cabazon cobbly clay loam, 20 to 60 percent slopes (Cof).—This soil is at elevations of 4,200 to 5,600 feet. Slopes range from 20 to 60 percent, but are dominantly 25 to 40 percent. They are typically 400 to 500 feet long. In many places they are broken by clifflike basalt outcrops. The profile of this soil is similar to the one described as representative of the Cabazon series, but this soil is steeper and its surface layer is cobbly instead of stony.

Inclusions of Gem soils make up about 15 percent of this mapping unit. Areas that are generally on top of the narrow, convex ridges, where slopes are less than 20 percent, make up about 5 percent of the unit. Also included are a few areas where slopes are more than 60 percent and a few small areas of shallow, extremely stony soil and rock outcrop.

The vegetation is mainly mesquite, canotia, cliffrose, shrub live oak, ceanothus, and side-oats grama. The grass cover is sparse.

Runoff is medium to rapid. The erosion hazard is moderate to high.

This Cabazon soil is used chiefly for livestock grazing and as wildlife habitat. Desirable browse, such as cliffrose and ceanothus, provides needed food for big game.

Intensified management could improve and increase the supply of palatable browse. This soil is in range herbage group 3, range improvement group 3, recreation group 3b, and capability subclass VIIe dryland.

Cabazon very stony clay loam, 0 to 20 percent slopes (CbD).—This soil is on uplands. It has the profile described as representative of the series. Elevation ranges from 5,600 to 7,000 feet. Slopes are dominantly less than 15 percent. In addition to the pinyon-juniper type vegetation commonly associated with Cabazon soils, many areas support poor-quality and stunted ponderosa pine. There is some Gambel oak.

Included with this soil in mapping are areas of Gem soils, small areas of Springerville and Broliar soils, some basalt rock outcrop, and some small areas where this soil is more than 50 percent coarse fragments. Inclusions make up about 10 percent of the total acreage.

Runoff is medium. The erosion hazard is low to moderate.

This Cabazon soil is used principally for livestock and wildlife. Following heavy storms, or after rapid snowmelt, the runoff yields water to streams and drainageways. This soil is in range herbage group 3, range improvement group 3, recreation group 3a, and capability subclass VIIs dryland.

Cabazon extremely rocky loam, 0 to 20 percent slopes (CeD).—This soil is on upland ridges and breaks. It is about 60 percent a Cabazon soil and 40 percent basalt outcrop. It differs in texture of the surface layer, but otherwise has a profile similar to the one described as representative of the series. Stones and cobblestones cover 20 to 25 percent of the surface area. Elevation ranges from 6,000 to 6,800 feet. This soil is closely associated with the Gem and Springerville soils and Basalt rock land.

Included with this soil in mapping are small areas of Gem soils and Venezia soils.

Runoff is medium and the erosion hazard is low.

This soil is used for livestock range and wildlife. It is moderately well suited to range herbage production, but is rated very low for revegetation. It is in range herbage group 3, range improvement group 3, recreation group 5a, and capability subclass VIIs dryland.

Chilson Series

The Chilson series consists of moderately steep to steep, well-drained soils that are 10 to 20 inches deep over bedrock. These soils formed on uplands in residuum derived chiefly from sandstone and shale of the Moenkopi Formation. Elevation ranges from 6,800 to 7,300 feet. Annual rainfall is 18 to 22 inches, the average annual temperature is 45° to 47° F., and the frost-free period is 100 to 120 days. The overstory is an open stand of ponderosa pine mixed with generous amounts of Gambel oak and alligator juniper. Douglas-fir grows on north-facing slopes. In places there is a thick cover of New Mexico locust. The dominant grasses are mountain muhly, pine dropseed, squirreltail, junegrass, and blue grama. These soils are associated with Broliar, Hogg, and McVickers soils.

In a representative profile the surface layer is dark reddish-gray cobbly clay loam about 3 inches thick. It is covered with a half-inch layer of partially decomposed pine needles and oak leaves. The subsoil is reddish-brown to red gravelly clay 14 inches thick. Calcareous shale or calcareous, fine-grained sandstone is at a depth of 17 inches.

Permeability is slow. The available water capacity is 2½ to 4 inches in the 10 to 20 inches of effective rooting depth. Runoff is medium to rapid, and the erosion hazard is moderate to high.

Chilson soils are used for timber, livestock, wildlife, range, and recreation.

Representative profile of Chilson cobbly clay loam, 20 to 45 percent slopes, in an area of ponderosa pine, NE¼ SW¼ sec. 10, T. 14 N., R. 10 E., Coconino County:

O1&O2—½ inch to 0, fresh and decomposing pine-needle and oak-leaf litter; neutral (pH 6.6).

A1—0 to 3 inches, dark reddish-gray (5YR 4/2) cobbly clay loam, dark reddish brown (5YR 2/2) moist; moderate, medium, granular structure; soft, friable, sticky and plastic; common very fine and fine roots; many micro and very fine interstitial pores; 20 percent cobblestones and 15 percent gravel; mildly alkaline (pH 7.6); abrupt, smooth boundary.

B21t—3 to 9 inches, reddish-brown (5YR 4/3) gravelly clay, dark reddish brown (5YR 3/2) moist; weak, fine and medium, subangular blocky structure; hard, firm, sticky and very plastic; common fine and medium roots; common micro and very fine interstitial pores and common very fine tubular pores; few thin clay films on ped faces and in pores; 20 percent gravel; noneffervescent; mildly alkaline (pH 7.4); clear, wavy boundary.

B22t—9 to 17 inches, red (2.5YR 4/6) gravelly clay, dark reddish brown (2.5YR 3/4) moist; moderate, medium, subangular blocky structure; hard, firm, sticky and plastic; common fine, medium, and coarse roots; common micro and very fine interstitial pores and common very fine tubular pores; few thin clay films on ped faces and in pores; 30 percent gravel; moderately alkaline (pH 8.0); abrupt, irregular boundary.

R—17 inches, fractured shale and fine-grained sandstone; dark red (2.5YR 3/6); extremely hard; some fine and medium roots along fracture planes.

Depth to bedrock ranges from 10 to 20 inches, but is commonly 17 inches. Coarse fragments on the surface vary in size and number. They are about 10 to 30 percent cobblestones, 10 to 30 percent gravel, and 5 to 20 percent stones. The number of coarse fragments typically increases with increasing slope. The A horizon is cobbly or stony clay loam or cobbly or stony loam. It is of 5YR to 7.5YR hue; value is 3 to 5 dry and 2 or 3 moist, and chroma is 2 or 3. Value in the B horizon is 3 or 4 dry and 2 or 3 moist, and chroma is 4 to 6.

Chilson cobbly clay loam, 20 to 45 percent slopes (ChE).—This soil is on hillsides where the Moenkopi Formation is exposed. Slopes are dominantly about 35 percent.

About 10 to 15 percent of the acreage of this soil is an included Broliar soil, near the tops of the slopes where basalt dominates. Also included are small areas of colluvial accumulations along toe slopes next to drainageways and some areas where shale is exposed.

This Chilson soil is in timber group 2b, range herbage group 3, range improvement group 3, recreation group 3b, and capability subclass VIe dryland.

Clover Springs Series

The Clover Springs series consists of nearly level to gently sloping, moderately well drained soils that are more than 60 inches deep over bedrock. These soils formed in alluvium derived mainly from limestone and sandstone and partly from basalt. They are in narrow drainage-ways, parks, and meadows in the ponderosa pine forest. Slopes are 0 to 5 percent. Elevation ranges from 6,800 to 7,700 feet. Annual rainfall ranges from 20 to 28 inches, the average annual temperature is about 44° F., and the frost-free period is 80 to 100 days. Vegetation is chiefly grass and forbs. Dominant species are Kentucky bluegrass, timothy, blue grama, western wheatgrass, sedges, clovers, and antennaria (pussytoes). Some aspen grows at the higher elevations. These soils are associated with Hogg, McVickers, and Soldier soils.

In a representative profile the surface layer is dark-gray silt loam or loam about 16 inches thick. The underlying layers are dark-gray or dark grayish-brown loam or heavy loam to a depth of 60 inches or more. The profile is noncalcareous throughout.

Permeability is moderate. The available water capacity is 8 to more than 10 inches in the 40 inches or more of effective rooting depth. After spring snowmelt and during periods of high rainfall, these soils are likely to be wet for extended periods.

Clover Springs soils are used as livestock range and wildlife habitat and as a source of water for lower lying areas.

Representative profile of Clover Springs silt loam, 0 to 5 percent slopes, in a grass- and forb-covered drainage-way, SW $\frac{1}{4}$ sec. 12, T. 14 N., R. 11 E., Coconino County:

- A1—0 to 16 inches, dark-gray (10YR 4/1) silt loam and loam, black (10YR 2/1) moist; weak, fine, granular structure; soft, friable, nonsticky and nonplastic; common very fine and few fine roots; many micro and very fine interstitial pores; neutral (pH 7.0); gradual, wavy boundary.
- C1—16 to 45 inches, dark-gray (10YR 4/1) heavy loam, very dark brown (10YR 2/2) moist; massive; slightly hard, friable, slightly sticky and nonplastic; very few fine roots; many micro and very fine interstitial pores; neutral (pH 7.0); gradual, wavy boundary.
- C2—45 to 60 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist; massive; slightly hard, friable, slightly sticky and nonplastic; very few fine roots; many micro and very fine interstitial pores; neutral (pH 7.0).

The A horizon is dominantly loam or silt loam. The underlying layers are heavy loam, loam, silt loam, or light clay loam. Both the A and C horizons are of 10YR or 7.5YR hue; value is dominantly 3 or 4 dry and 2 moist, and chroma ranges from 1 to 3. Typically, this soil is dark colored to a depth of 40 inches or more. In some areas it is highly stratified with loam and silt loam and lenses of fine gravel.

Clover Springs silt loam, 0 to 5 percent slopes (C1B).—

This soil is on benches and stream bottoms along drainage-ways (fig. 7). Slopes are typically 2 to 3 percent, but increase to as much as 5 percent near the outer edges of the alluvial deposits. In places where the alluvium is adjacent to basalt, small areas of Luth soils are included in mapping.

Runoff is slow. The erosion hazard is moderate to high. Many areas are extensively and actively gullied.

This Clover Springs soil is in range herbage group 1,

range improvement group 1, recreation group 1c, and capability subclass V1c dryland.

Cornville Series

The Cornville series consists of nearly level to gently sloping, well-drained soils that are more than 60 inches deep over bedrock. These soils formed on alluvial fans, benches, and terraces in mixed alluvium derived from sandstone and limestone and some basalt. Slopes are 0 to 5 percent. Elevation ranges from 3,200 to 3,600 feet. Annual rainfall is 11 to 13 inches, the average annual temperature is about 61° F., and the frost-free period is 220 to 230 days. The vegetation is mesquite, creosotebush, snakeweed, yucca, tobosa, side-oats grama, and black grama. These soils are associated with Anthony, Glendale, and Hantz soils.

In a representative profile the surface layer is brown fine sandy loam about 3 inches thick. The subsoil is yellowish-red to reddish-brown sandy clay loam about 27 inches thick. The substratum is pinkish-white, strongly calcareous gravelly loam that extends to a depth of 60 inches or more.

Permeability is moderately slow. The available water capacity is 9 to 11 inches in the 60 inches or more of effective rooting depth.

Cornville soils are used for irrigated crops, for winter range, and as small game habitat.

Representative profile of Cornville fine sandy loam, 0 to 5 percent slopes, in an area of range, SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5, T. 13 N., R. 5 E., Yavapai County:

- A1—0 to 3 inches, brown (7.5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) moist; weak, medium, platy structure breaking to moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; many micro and very fine interstitial pores; moderately alkaline (pH 8.2); clear, smooth boundary.
- B1—3 to 10 inches, yellowish-red (5YR 5/6) sandy clay loam, dark reddish brown (5YR 3/4) moist; weak, medium, subangular blocky structure; hard, friable, slightly sticky and slightly plastic; common fine roots; common very fine and fine interstitial pores; common thin clay films in pores and on ped faces; moderately alkaline (pH 8.2); clear, smooth boundary.
- B21t—10 to 20 inches, yellowish-red (5YR 5/6) sandy clay loam, dark reddish brown (5YR 3/4) moist; weak, medium, prismatic structure parting to a moderate, medium, subangular blocky structure; hard, friable, slightly sticky and plastic; few fine roots; many very fine and fine interstitial and tubular pores; many thin clay films on ped faces; moderately alkaline (pH 8.2); clear, wavy boundary.
- B22t—20 to 30 inches, reddish-brown (5YR 5/4) light sandy clay loam, dark reddish brown (5YR 3/4) moist; moderate, medium and coarse, subangular blocky structure; hard, friable, slightly sticky and plastic; few fine roots; many very fine and fine interstitial and tubular pores; common thin clay films in pores and on ped faces; few, fine, white lime filaments; slightly effervescent; moderately alkaline (pH 8.4); abrupt, wavy boundary.
- Cca—30 to 60 inches, pinkish-white (5YR 8/2) gravelly loam, light reddish brown (5YR 6/3) moist; massive; hard, firm, sticky and slightly plastic; few very fine roots; few very fine tubular pores; 25 percent gravel; lime content is more than 15 percent; violently effervescent; moderately alkaline (pH 8.4).

The A horizon is fine sandy loam, sandy loam, or sandy clay loam. It is dominantly of 7.5YR and 5YR hue,



Figure 7.—Grass-covered Clover Springs silt loam.

but ranges to 10YR; value ranges from 5 to 7 dry and 3 to 5 moist, and chroma is 3 and 4. The B horizon is of 7.5YR to 5YR hue; value is 5 or 6 dry and 3 or 4 moist, and chroma ranges from 3 to 6. The B_{2t} horizon is heavy sandy loam or sandy clay loam. It is dominantly of moderate structure, but ranges from weak to strong.

Cornville fine sandy loam, 0 to 5 percent slopes (CoB).—This soil is on smooth alluvial fans and terraces that are about 20 to 100 feet above the present stream channel in the Verde River Valley. Slopes range from 0 to 5 percent, but are dominantly 1 to 3 percent. Some areas have been leveled.

Included with this soil in mapping are areas of Anthony and Glendale soils, which make up 10 to 15 percent of the total acreage, and areas, near the edges of terraces particularly along the Verde River, of a Cornville soil that is no more than 25 inches deep over a lime zone.

Runoff is slow. The erosion hazard is moderate.

This Cornville soil is in range herbage group 3, range improvement group 2, recreation group 2a, and capability subclasses IIe irrigated and VIe dryland.

Cowan Series

The Cowan series consists of nearly level, excessively drained, stratified soils that are more than 60 inches deep over bedrock. These soils formed in mixed sandstone and

limestone alluvium on flood plains and low terraces adjacent to the Verde River and West Clear Creek. Slopes are 0 to 2 percent. Elevation ranges from 3,000 to 3,500 feet. Annual rainfall is about 12 inches, the average annual temperature is about 61° F., and the frost-free period is 200 to 230 days. The vegetation is cottonwood, willow, sand dropseed, and annuals. These soils are associated with Anthony, Arizo, Glendale, and Hantz soils.

In a representative profile the surface layer is reddish-yellow loamy fine sand about 20 inches thick. Below this and extending to a depth of 5 feet or more is mainly reddish-yellow loamy sand. The profile is stratified and is slightly to strongly effervescent.

Permeability is rapid. The available water capacity is 4 to 5 inches in the 60 inches of effective rooting depth. In places the water table rises to the lower part of the profile during periods when the river is high.

The Cowan soils in the Long Valley Area are mapped with Arizo soils. They are used as range and irrigated pasture.

Representative profile of Cowan loamy fine sand in an area of Cowan and Arizo soils, NE¼ sec. 7, T. 13 N., R. 5 E., Yavapai County:

A1—0 to 20 inches, reddish-yellow (5YR 6/6) loamy fine sand, yellowish red (5YR 4/6) moist; single grain;

loose dry and moist; few very fine roots; few fine tubular pores and many very fine interstitial pores; slightly effervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

C1—20 to 24 inches, light reddish-brown (5YR 6/4) fine sandy loam, yellowish red (5YR 5/6) moist; single grain; loose dry and moist; few very fine roots; few fine tubular pores; strongly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C2—24 to 60 inches, reddish-yellow (5YR 6/6) loamy sand, yellowish red (5YR 4/6) moist; single grain; loose dry and moist; few fine and many very fine interstitial pores; slightly effervescent; moderately alkaline (pH 8.2).

The A horizon is loamy fine sand or fine sand. It is dominantly of 5YR hue; value is 5 or 6 dry and 3 to 5 moist, and chroma is 3 to 6. The C horizon is loamy sand, light sandy loam, or fine sandy loam.

Cowan and Arizo soils (Cr).—This mapping unit is a mixture of Cowan loamy sands and sands, Arizo cobbly and gravelly sands, and cobblestones, stones, and pebbles. It is on bottom land adjacent to the Verde River and West Clear Creek and also in the channels of those streams.

The composition of the mapping unit varies widely from place to place. Some areas are Cowan soil, some are Arizo soil, and some contain both soils. In places one soil is atop the other. The proportion of each soil in each mapped area changes with each freshet or other flow of high water. The Arizo soil is described under the heading "Arizo Series."

These soils are subject to overflow. Even so, they support cottonwoods and willows that provide shade for livestock, and the groves are often used as picnic areas during periods when water is low. The Arizo soil is a source of sand and gravel.

The Cowan soil is in range herbage group 4, range improvement group 3, recreation group 4, and capability subclass IIIs irrigated and VIIs dryland.

The Arizo soil is in range herbage group 4, range improvement group 3, recreation group 4, and capability subclass VIIs dryland.

Disterheff Series

The Disterheff series consists of moderately steep and steep, well-drained soils that are more than 40 inches deep over bedrock. These soils formed in colluvium weathered from basalt, sandstone, and shale. They are on the sides of buttes and mesas. Slopes are 20 to 45 percent. Elevation ranges from 6,400 to 6,700 feet. Annual rainfall ranges from 13 to 16 inches, the average annual temperature is 48° to 54° F., and the frost-free period is 140 to 180 days. The overstory is a dense stand of Utah and alligator juniper and pinyon pine. The understory is blue grama, side-oats grama, squirreltail, algerita, cliffrose, prickly-pear, and various forbs. These soils are associated with Gem, Navajo, Springerville, and Winona soils.

In a representative profile the surface layer is brown very stony clay loam about 4 inches thick. The subsoil is reddish-brown and red clay and gravelly clay that extends to a depth of 40 inches. The substratum is pink, strongly calcareous very gravelly loam that extends to a depth of 60 inches or more.

Permeability is slow to very slow. The available water capacity is 7 to 12 inches in the 40 inches or more of effective rooting depth.

Disterheff soils are used for wildlife and summer livestock range.

Representative profile of Disterheff very stony clay loam, 20 to 45 percent slopes, under pinyon and juniper, NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30, T. 16 N., R. 12 E., Coconino County:

A1—0 to 4 inches, brown (10YR 4/3) very stony clay loam, very dark grayish brown (10YR 3/2) moist; moderate, fine, granular structure; soft, friable, sticky and plastic; few fine roots; many fine and very fine interstitial pores; approximately 20 percent stones, 40 percent cobblestones, and 25 percent gravel; very slightly effervescent; moderately alkaline (pH 8.0); abrupt, smooth boundary.

B1—4 to 8 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) moist; moderate, fine and medium, angular and subangular blocky structure; hard, friable, sticky and very plastic; few fine roots and common medium roots; common micro and very fine interstitial pores; few thin clay films on ped faces; approximately 10 percent gravel; slightly effervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

B21t—8 to 14 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/4) moist; moderate, medium and coarse, subangular blocky structure; very hard, very firm, sticky and very plastic; common medium roots and few fine roots; common micro and very fine interstitial pores; few thin clay films on ped faces; about 3 or 4 percent gravel; strongly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

B22t—14 to 23 inches, reddish-brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate, medium, subangular blocky structure; very hard, very firm, sticky and very plastic; few fine, medium, and coarse roots; common micro and very fine interstitial pores; many moderately thick clay films on ped faces; approximately 15 percent cobblestones and 20 percent gravel; strongly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

B23tca—23 to 40 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; many, large, prominent, pink mottles, (5YR 8/3) dry, (5YR 7/4) moist; moderate, medium and coarse, subangular blocky structure; very hard, very firm, sticky and very plastic; very few fine, medium, and coarse roots; few micro interstitial pores; many moderately thick clay films on ped faces; about 3 or 4 percent gravel; many large line segregations; slightly effervescent soil material, line segregations violently effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

Cca—40 to 72 inches, pink (5YR 8/4) very gravelly loam, light reddish brown (5YR 6/4) moist; massive; hard, friable, slightly sticky and plastic; approximately 75 percent shale and sandstone fragments; violently effervescent; strongly alkaline (pH 8.5).

In most places the soil is 40 to more than 70 inches deep over sandstone and shale. Cobblestones and stones cover 15 to 40 percent of the surface area. Some profiles are 15 to 20 percent gravel and cobblestones. The A horizon is cobbly, stony, very cobbly, or very stony clay loam or clay. It is dominantly of 5YR hue, but ranges from 5YR to 10YR; value is 4 or 5 dry, and chroma is 2 to 4. The Cca horizon is more than 15 percent carbonates.

Disterheff very stony clay loam, 20 to 45 percent slopes (DeE).—This soil is on sides of buttes and mesas that are basalt cap rock over thinly bedded Moenkopi Sandstone and Shale. At least 75 percent of the acreage is covered with pinyon and juniper trees.

Included with this soil in mapping are small areas of Tortugas soils and areas, at the base of the steeper slopes, where slopes are less than 20 percent.

Runoff is rapid. The erosion hazard is dominantly moderate, but is high where the surface is not protected by coarse fragments.

This Disterheff soil is in range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIs dryland.

Dye Series

The Dye series consists of nearly level to strongly sloping, well-drained soils that are 10 to 20 inches deep over bedrock. The soils formed in residuum weathered from Coconino Sandstones. They are on uplands. Slopes range from 0 to 20 percent. Elevation ranges from 6,800 to 6,900 feet. Annual rainfall is 12 to 16 inches, the average annual temperature is 55° to 58° F., and the frost-free period is 160 to 200 days. The soils are in a pinyon-juniper zone where there are many nearly open areas of grassland. The overstory is pinyon and juniper. The understory is chiefly blue grama, three-awn, wolftail, snakeweed, fringed sage, and some cliffrose, skunkbush, and pricklypear. These soils are associated with Jacks, Lynx, Tortugas, and Winona soils.

In a representative profile, the surface layer is brown fine sandy loam about 2 inches thick. The subsoil is brown fine sandy loam, reddish-brown sandy clay loam, and yellowish-red clay that overlies sandstone bedrock at a depth of about 19 inches. The profile is noncalcareous throughout.

Permeability is slow. The available water capacity is 2 to 4 inches in the 10 to 20 inches of effective rooting depth.

Dye soils are used for range and wildlife.

Representative profile of Dye fine sandy loam, 0 to 10 percent slopes, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 23, T. 15 N., R. 12 E., Coconino County:

A1—0 to 2 inches, brown (7.5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) moist; weak, fine, platy structure parting to moderate, fine, granular structure; slightly hard, friable, nonsticky and slightly plastic; many very fine and fine roots; many fine interstitial pores; common gravel; neutral (pH 6.8); abrupt, smooth boundary.

B1—2 to 4 inches, brown (7.5YR 5/4) heavy fine sandy loam, dark reddish brown (5YR 3/4) moist; moderate, medium, granular structure and weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots; common fine interstitial pores and common very fine and fine tubular pores; few thin clay films on ped faces and as bridges; neutral (pH 7.0); clear, smooth boundary.

B2t—4 to 10 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) moist; weak, medium, subangular blocky structure; hard, friable, sticky and plastic; common very fine, fine, and medium roots; common very fine and fine tubular pores and common fine interstitial pores; common thin clay films on ped faces and in pores; mildly alkaline (pH 7.6); clear, wavy boundary.

B22t—10 to 19 inches, yellowish-red (5YR 4/6) clay, dark reddish brown (5YR 3/4) moist; moderate, fine and medium, angular and subangular blocky structure; hard, firm, sticky and very plastic; common very fine and fine tubular pores and few fine interstitial

pores; common thin clay films on ped faces, in pores, and as bridges; approximately 10 percent gravel and cobbles; mildly alkaline (pH 7.4); abrupt, irregular boundary.

R—19 inches, pale-brown to light-brown (10YR 6/3-7.5YR 6/4), massive sandstone bedrock.

Gravel cover on the surface ranges from a few pebbles to approximately 30 percent. The A horizon is fine sandy loam, loam, or gravelly or very stony fine sandy loam. It is of 5YR to 10YR hue; value is 5 or 6 dry and 3 or 4 moist, and chroma is 2 to 6. The B2t horizon, when mixed, is more than 35 percent clay; the clay content increases with increasing depth. This horizon is of 2.5YR to 7.5YR hue; value is 4 to 5 dry and 3 to 4 moist, and chroma is 4 to 6.

Dye fine sandy loam, 0 to 10 percent slopes (DfC).—This soil is on uplands that are broken by shallow drainageways. Slopes are dominantly 1 to 3 percent, but range from 0 to 10 percent. A few scattered stones cover the surface. This soil has the profile described as representative of the series.

Included areas of Tortugas soils make up 5 to 10 percent of the total acreage of this soil. Also included are small areas of Winona soils; areas of a soil that resembles this Dye soil, but is more than 20 inches deep over sandstone; some areas of Jacks soils; areas of Lynx soils in the narrow drainageways; and some areas where slopes exceed 10 percent.

Runoff is medium. The erosion hazard is moderate.

This Dye soil is in range herbage group 3, range improvement group 2, recreation group 3a, and capability subclass VIe dryland.

Dye very stony fine sandy loam, 0 to 20 percent slopes (DvD).—This soil is on uplands that are dissected by numerous shallow drainageways. Slopes are dominantly 10 to 15 percent. Stones cover 15 to 25 percent of the surface area, and rock outcrop about 10 percent.

About 10 percent of the acreage of this soil is included areas of Tortugas soils; 2 percent is areas of Lynx soils; and about 5 percent is a soil that is medium and moderately fine textured, but otherwise resembles this Dye soil.

Runoff is medium, and the erosion hazard is moderate to high.

This Dye soil is used for livestock range and wildlife. It is in range herbage group 3, range improvement group 3, recreation group 3a, and capability subclass VIi dryland.

Friana Series

The Friana series consists of nearly level, moderately well drained soils that are 35 to 60 inches deep over very gravelly, cindery clay. These soils formed in mixed sediments derived from volcanic ash, cinder, and basalt. They are in old lake beds and depressions. The slope gradient is 0 to 2 percent. Elevation ranges from 6,900 to 7,500 feet. Annual rainfall ranges from 20 to 24 inches, the average annual temperature is about 45° F., and the frost-free period is 80 to 100 days. These soils are mostly in open parks and meadows in the basaltic part of the ponderosa pine forest. Plant cover consists chiefly of mountain brome, Arizona fescue, blue grama, and introduced wheatgrass. Iris is common in the more moist areas. These soils are associated with Broliar, Hogg, Siesta, and Sponseller soils.

In a representative profile the surface layer is brown clay loam about 3 inches thick. The subsoil is 36 inches thick and is mostly very dark brown and dark brown clay. It is mottled and gravelly below a depth of 28 inches. The substratum is very gravelly and cindery clay of variegated color. It extends to a depth of 54 inches or more. The profile is noncalcareous throughout. It ranges from slightly acid to mildly alkaline.

Sometimes these soils are wet or ponded for extended periods following spring snowmelt. Permeability is slow. The available water capacity is 10 to 12 inches in the 54 inches of effective rooting depth.

Friana soils are used as summer range for livestock and as a source of food for wildlife.

Representative profile of Friana clay loam, 0 to 2 percent slopes, in an open park in the ponderosa pine forest, SE $\frac{1}{4}$ sec. 14, T. 16 N., R. 9 E., Coconino County:

A1—0 to 3 inches, brown (10YR 4/3) clay loam, dark brown (10YR 3/3) moist; weak, medium, platy structure parting to strong, medium, granular structure; soft, friable, slightly sticky and slightly plastic; many very fine roots; common micro and very fine interstitial pores; slightly acid (pH 6.4); abrupt, smooth boundary.

B1—3 to 9 inches, very dark gray (10YR 3/1) clay, very dark brown (10YR 2/2) moist; strong, fine, angular and subangular blocky structure; hard, friable, sticky and plastic; common very fine and few fine roots; common micro and very fine interstitial pores; neutral (pH 6.8); abrupt, smooth boundary.

B21t—9 to 23 inches, very dark brown (10YR 2/2) clay, very dark brown (10YR 2/2) moist; weak, fine and medium, prismatic structure parting to moderate, medium and coarse, angular blocky structure; very hard, firm, sticky and very plastic; very few fine and very fine roots; common micro and very fine interstitial pores; continuous moderately thick clay films on ped faces; neutral (pH 7.0); clear, smooth boundary.

B22t—23 to 28 inches, dark-brown (7.5YR 3/2) clay, dark brown (7.5YR 3/2) moist; moderate, medium and coarse, angular blocky structure; very hard, very firm, sticky and very plastic; very few very fine roots; very few very fine tubular pores and common micro and very fine interstitial pores; continuous moderately thick clay films on ped faces; approximately 10 percent cobblestones; neutral (pH 7.0); clear, wavy boundary.

B23t—28 to 32 inches, dark-brown (7.5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; yellowish-red (5YR 4/6) mottles, yellowish red (5YR 5/8) moist; massive; very hard, firm, sticky and plastic; very few very fine roots; common micro and very fine interstitial pores; common to many pressure faces, few small slickensides; approximately 30 percent gravel and many spheroidal manganese concretions; neutral (pH 7.0); clear, wavy boundary.

B3t—32 to 39 inches, strong-brown (7.5YR 5/6) gravelly clay, brown (7.5YR 5/4) moist; reddish-brown (5YR 4/4) mottles, dark reddish brown (5YR 3/4) moist; weak, medium, subangular blocky structure; very hard, very firm, sticky and plastic; very few very fine interstitial pores; approximately 40 percent gravel; slightly effervescent; mildly alkaline (pH 7.4); gradual, wavy boundary.

C1—39 to 54 inches, variegated reddish-brown (5YR 4/4), brownish-yellow (10YR 6/6), and black (10YR 2/1) very gravelly, cindery clay, yellowish brown (10YR 5/6) and black (10YR 2/1) moist; massive; very hard, firm, sticky and plastic; many micro and very fine interstitial pores; approximately 85 percent gravel or cinders; mildly alkaline (pH 7.4); clear, wavy boundary.

C2—54 inches, cinders.

The A horizon is clay loam, silt loam, or loam. Some profiles have no mottles or iron stains in the lower part of the B horizon. A few contain a small amount of gravel.

Friana clay loam, 0 to 2 percent slopes (FrA).—This soil is in open parks, for example, Bargeman Park, Mahan Park (fig. 8), and Harris Park, and in meadows in the ponderosa pine forest. The soil is mostly free of coarse surface fragments, but in some isolated areas it is gravelly and cobbly.

Runoff is slow. The erosion hazard is slight. The only evidence of erosion is the cutting of shallow, weakly defined drainage channels.

This soil is in range herbage group 1, range improvement group 1, recreation group 2a, and capability subclass VIIs dryland.

Gem Series

The Gem series consists of nearly level to rolling and hilly, well-drained soils that are 22 to 40 inches deep over bedrock. These soils formed on uplands in residuum weathered mainly from basalt and cinders (fig. 9). Slopes range from 0 to 20 percent. Elevation ranges from 5,000 to 7,000 feet. Annual rainfall ranges from 14 to 20 inches, the average annual temperature is 49° to 53° F., and the frost-free period is 170 to 200 days. Vegetation is pinyon pine, Utah juniper, blue grama, side-oats grama, squirrel-tail, fringed sage, snakeweed, and buckwheat. These soils are associated with Disterheff, Cabezon, Springerville, and, at the higher elevations, Broliar soils.

In a representative profile the surface layer is brown cobbly clay loam about 3 inches thick. The subsoil is mainly dark reddish-brown, cobbly and gravelly clay that extends to basalt bedrock at a depth of 25 inches.

Permeability is slow. The available water capacity is 5 to 8 inches in the 22 to 40 inches of effective rooting depth.

Gem soils are used for livestock range, wildlife, and water yield.

Representative profile of Gem cobbly clay loam, 0 to 20 percent slopes, in an area of native range, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 33, T. 16 N., R. 11 E., Coconino County:

A1—0 to 3 inches, brown (10YR 5/3) cobbly clay loam, dark brown (10YR 3/3) moist; moderate, medium, platy structure parting to moderate, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; many micro and very fine interstitial pores; approximately 10 percent gravel and 20 percent cobblestones; mildly alkaline (pH 7.4); clear, smooth boundary.

B1—3 to 9 inches, dark reddish-brown (5YR 3/3) clay loam, dark reddish brown (5YR 3/3) moist; moderate, medium, subangular blocky structure; hard, friable, sticky and plastic; few very fine and fine roots; many micro and very fine interstitial pores and common very fine and fine tubular pores; common thin clay films on ped faces; approximately 10 percent cobblestones; mildly alkaline (pH 7.8); clear, smooth boundary.

B21t—9 to 21 inches, dark reddish-brown (5YR 3/4) cobbly and gravelly clay, dark reddish brown (5YR 3/4) moist; moderate, medium, prismatic structure and moderate, medium, angular blocky structure; very hard, very firm, sticky and very plastic; very few fine and few medium roots; common micro and very fine interstitial pores and few very fine and fine tubular pores; continuous thin clay films on ped



Figure 8.—Friana clay loam in Mahan Park. Broliar soils support the tree cover in the background.

faces and in pores; approximately 15 percent cobblestones and 25 percent gravel; moderately alkaline (pH 8.0); clear, wavy boundary.

B22tca—21 to 25 inches, reddish-brown (5YR 4/3) very stony clay, dark reddish brown (5YR 3/3) moist; moderate, fine and medium, angular blocky structure; very hard, very firm, sticky and very plastic; very few very fine and fine roots; common micro and very fine interstitial pores and few very fine and fine tubular pores; few thin clay films on ped faces and in pores; common fine and medium manganese staining; approximately 10 percent gravel and 25 percent stones; slightly effervescent; moderately alkaline (pH 8.0); abrupt, wavy boundary.

R—25 inches, slightly weathered basalt rock.

The A horizon is chiefly cobbly clay loam, but in some profiles it is gravelly clay loam or gravelly and cobbly loam. It is of 10YR or 7.5YR hue; value is 4 or 5 dry and 2 or 3 moist, and chroma is 2 or 3. The B horizon ranges from cobbly, gravelly, and stony heavy clay loam to clay. Some profiles are as much as 20 percent cobblestones, 30 percent gravel, and 15 to 30 percent stones. Stones typically occur in the lower part of the B horizon. Depth to basalt or cinders is commonly 24 to 36 inches, but ranges from 22 to 40 inches.

Gem cobbly clay loam, 0 to 20 percent slopes (GcD).—

This soil is on uplands in the plateau region above the Mogollon Rim. Slopes range from 0 to 20 percent, but are dominantly 10 percent or less. Cobblestones cover 15 to 20 percent of the surface area, and gravel 10 to 20 percent.

Included areas of Springerville soils make up as much

as 10 percent of the total acreage of this soil. Also included are small areas of Cabezon and Waldroup soils.

Runoff is slow to medium. The erosion hazard is moderate.

This Gem soil is in range herbage group 2, range improvement group 1, recreation group 2a, and capability subclass VIc dryland.

Glendale Series

The Glendale series consists of nearly level to sloping, well-drained soils that are more than 60 inches deep over bedrock. These soils formed on alluvial fans in calcareous silty alluvium. Slope gradients are 0 to 10 percent. Elevation ranges from 3,200 to 4,000 feet. Annual rainfall ranges from 11 to 13 inches, the average annual temperature is 61° F., and the frost-free period is 200 to 230 days. Dense, vigorous stands of creosotebush are common. Among other plants are mesquite, Russian-thistle, fluffgrass, black grama, tobosa, and snakeweed. These soils are associated with Anthony, Guest, Hantz, and Retriever soils.

In a representative profile the surface layer is light brownish-gray gravelly silt loam about 2 inches thick. Below this and extending to a depth of 60 inches or more is pale-brown silty clay loam. The profile is strongly calcareous and moderately alkaline throughout.



Figure 9.—Gem soils on Mud Tanks Mesa.

Permeability is moderately slow. The available water capacity is 10 to 12 inches in the 60 or more inches of effective rooting depth.

Glendale soils are used as winter range for livestock and as wildlife habitat. Some areas are irrigated.

Representative profile of Glendale gravelly silt loam, 0 to 5 percent slopes, in an area of range, SW $\frac{1}{4}$ sec. 10, T. 13 N., R. 5 E., Yavapai County:

- A1—0 to 2 inches, light brownish-gray (10YR 6/2) gravelly silt loam, dark grayish brown (10YR 4/2) moist; weak, medium, platy structure parting to moderate, medium, granular structure; soft, friable, sticky and slightly plastic; common fine and medium roots; many very fine interstitial pores and common very fine and fine tubular pores; 20 percent fine gravel; violently effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.
- C1—2 to 27 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 4/3) moist; massive; slightly hard, friable, sticky and plastic; common fine, medium, and coarse roots; many very fine interstitial pores and common very fine and fine tubular pores; violently effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.
- C2—27 to 68 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) moist; massive; slightly hard, friable, sticky and plastic; few medium and coarse roots; many very fine interstitial pores and common very fine and fine tubular pores; violently effervescent; moderately alkaline (pH 8.4).

The A horizon is dominantly gravelly silt loam, but in places is gravelly fine sandy loam or gravelly loam. The C horizon is heavy loam, heavy silt loam, light silty clay loam, or light clay loam. The profile is of 10YR or 7YR hue; value is 5 to 7 dry and 4 or 5 moist, and chroma is 2 to 4 dry or moist.

Glendale gravelly fine sandy loam, 0 to 10 percent slopes (GdC).—This soil is in narrow drainageways between limestone mesas. It is closely associated with the sloping Retriever soils. The surface layer is gravelly fine sandy loam. The lower part of the underlying material contains lime nodules. Deep, extensive gullies have formed in most areas.

Included with this soil in mapping are areas of Guest soils and areas of soils that have fine sandy loam underlying layers. These inclusions make up about 20 percent of the mapping unit.

This Glendale soil is used as range and wildlife habitat. It is in range herbage group 2, range improvement group 2, recreation group 4, and capability subclass VIe dryland.

Glendale gravelly silt loam, 0 to 5 percent slopes (GeB).—This soil occupies alluvial fans and narrow strips of bottom land in the Verde Valley (fig. 10). Most areas are severely gullied, and many of the gullies are more than 10 feet deep. Gravel covers about 20 percent of



Figure 10.—Glendale gravelly silt loam. This area is irrigated and used as pasture.

the surface area. This soil has the profile described as representative of the series.

Within this mapping unit are small inclusions of a Hantz silty clay, a Glendale gravelly fine sandy loam, and, near a gypsum mining area, a Glendale soil that contains some gypsum.

Runoff is slow. The erosion hazard is high.

This Glendale soil is used as winter range for livestock and as wildlife habitat. It is in range herbage group 2, range improvement group 2, recreation group 4, and capability subclasses IIe irrigated and VIe dryland.

Graham Series

The Graham series consists of gently sloping to steep, well-drained soils that are 10 to 20 inches deep over bedrock. These soils formed on uplands and mountainsides in cinders and residuum weathered from basalt. Slopes are 0 to 60 percent. Elevation ranges from 3,800 to 4,400 feet. Annual rainfall is 12 to 14 inches, the average annual temperature is 58° to 61° F., and the frost-free period is 200 to 230 days. The vegetation is mesquite, canotia, pricklypear, cholla, juniper, shrub live oak, twinberry, wolfberry, hairy grama, black grama, side-oats grama, and curly mesquite. These soils are associated with Cabezon, House Mountain, Penthouse, and Rimrock soils.

In a representative profile the surface layer is dark-brown cobbly clay loam about 2 inches thick. The subsoil is dark-brown clay. Basalt or welded cinders is at a depth of 12 inches.

Permeability is slow. The available water capacity is 2 to 3 inches in the 10 to 20 inches of effective rooting depth.

Graham soils are used for livestock range and wildlife.

The Graham soils in the Long Valley Area are mapped only with the House Mountain soils.

Representative profile of Graham cobbly clay loam, 0 to 30 percent slopes, in an area of native range, NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 36, T. 13 N., R. 5 E., Yavapai County:

A1—0 to 2 inches, dark-brown (7.5YR 4/2) cobbly clay loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; many very fine and fine interstitial pores; 20 percent gravel and cobbles; mildly alkaline (pH 7.6); clear, smooth boundary.

B21t—2 to 6 inches, dark-brown (7.5YR 4/2) light clay, dark brown (7.5YR 3/2) moist; moderate, fine and medium, subangular blocky structure; hard, friable, sticky and plastic; common very fine and fine roots; common very fine and fine tubular pores; 10 percent cobbles; few thin clay films on ped faces and in pores; mildly alkaline (pH 7.6); clear, smooth boundary.

B22t—6 to 12 inches, dark-brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) moist; moderate, medium and coarse, subangular blocky structure; hard, friable, sticky and plastic; common very fine and fine roots; common very fine and fine tubular pores; mildly alkaline (pH 7.8); abrupt, irregular boundary.

R—12 inches, slightly fractured, hard basalt rock.

The A horizon is cobbly clay loam, cobbly or stony silty clay loam, or cobbly loam. In some profiles it is gravelly. It is of 10YR to 5YR hue; value is 3 to 5 dry and 2 or 3 moist, and chroma is 2 or 3. The Bt horizon is heavy clay loam, light clay, or clay. It is of 7.5YR to 2.5YR hue. The depth to basalt or welded cinders is typically 12 to 17 inches but ranges from 10 to 20 inches. In some places there is a thin layer of lime just above the basalt.

Graham and House Mountain soils, 0 to 30 percent slopes (GhD).—These are very shallow and shallow, gravelly, cobbly, and stony soils, chiefly in the area below the Mogollon Rim. Slopes range from 0 to 30 percent, but are dominantly 10 to 20 percent. Stones cover 20 to 30 percent of the surface in most areas, 15 percent in some, and as much as 50 percent in others. The stones are 25 to 60 percent pebbles and 10 to 15 percent cobblestones.

The two major soils are Graham cobbly clay loam and House Mountain stony loam. There is no uniformity of soil pattern. The shallow Graham soil is dominant. It has the profile described as representative of the Graham series. The House Mountain soil is described under the heading "House Mountain Series."

Included with these soils in mapping are small tracts of Rimrock soils in saddlelike areas and depressions; a few spots of moderately deep soils that formed over deeper bedrock planes; areas of rock outcrop, which make up 5 percent of the total acreage; and areas where the soils are underlain by ash and tuff.

From 20 to 30 percent of the acreage is bare of vegetation (fig. 11). Runoff is medium to rapid, and the erosion hazard is moderate. A few shallow gullies have formed, mostly in the cindery, reddish-colored soils.

These Graham and House Mountain soils are used for livestock range and wildlife. They are in range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIe dryland.

Graham and House Mountain soils, 30 to 60 percent slopes (GhF).—These soils are similar to Graham and House Mountain soils, 0 to 30 percent slopes, but slopes are dominantly 40 percent or more, and in some areas the underlying material is volcanic ash, tuff, or rhyolite. This material has been exposed by erosion in places.

More than 30 percent of the acreage is barren. Runoff is rapid, and the erosion hazard is high.

These Graham and House Mountain soils are used for range. They are in range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIe dryland.

Guest Series

The Guest series consists of nearly level to gently sloping, well-drained soils that formed in recent alluvium weathered from basalt and limestone. These soils are in drainageways and on terraces and small alluvial fans. Slopes are 0 to 5 percent. Elevation ranges from 3,300 to 4,000 feet. Annual precipitation is 11 to 13 inches, the

average annual temperature is 61° F., and the frost-free period is 200 to 230 days. The vegetation is partly mesquite, yucca, and Russian-thistle, but dominantly dense patches of tobosa. These soils are associated with Glendale, Hantz, Bridge, and Retriever soils.

In a representative profile the surface layer is brown clay about 10 inches thick. Below this and extending to a depth of 60 inches or more is brown and grayish-brown clay. The profile is calcareous and moderately alkaline throughout.

Permeability is slow. The available water capacity is 10 to 12 inches in the 60 inches or more of effective rooting depth.

Guest soils are used as winter livestock range and as habitat for upland birds and small game.

Representative profile of Guest clay, 0 to 5 percent slopes, in an area of range, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 20, T. 14 N., R. 6 E., Yavapai County:

A1—0 to 10 inches, brown (10YR 5/3) light clay, dark brown (7.5YR 3/2) moist; weak, fine, subangular blocky structure; slightly hard, friable, sticky and plastic; many very fine and fine roots; few very fine interstitial and tubular pores; violently effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C1—10 to 28 inches, brown (10YR 5/3) clay, dark brown (10YR 3/3) moist; massive; hard, friable, sticky and plastic; common fine and medium roots; few very fine interstitial and tubular pores; few, fine, white lime filaments, few fine pebbles; violently effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

C2—28 to 62 inches, grayish-brown (10YR 5/2) clay, very dark grayish brown (10YR 3/2) moist; massive; very hard, firm, sticky and plastic; very few fine roots; few very fine interstitial and tubular pores; common, fine, white lime filaments; violently effervescent; moderately alkaline (pH 8.2).

The A horizon is clay, silty clay, or clay loam. The C horizon is clay or heavy clay loam. The profile is of 7.5YR and 10YR hue; value is 4 or 5 dry and 3 or 4 moist, and chroma is 2 to 4. Effervescence ranges from strong to violent.

Guest clay, 0 to 5 percent slopes (GuB).—This soil is on alluvial deposits. It is near the northern boundary of the survey area in the Verde Valley.

Inclusions of highly stratified loams, sandy loams, and clay loams that have gravel lenses throughout the profile and are of 10YR to 5YR hue make up 15 percent of some areas, and inclusions of Bridge, Glendale, and Hantz soils make up 5 percent of some. Total inclusions amount to no more than 5 percent of the total acreage of this soil.

Runoff is slow. The erosion hazard is moderate to high.

This Guest soil is in range herbage group 2, range improvement group 2, recreation group 4, and capability subclass VIe dryland.

Hantz Series

The Hantz series consists of gently sloping, well-drained soils that formed in strongly calcareous sediments weathered from shale and limestone of the Verde Formation. These soils are on alluvial fans. Slopes are 0 to 5 percent. Elevation is 3,100 to 3,300 feet. Annual rainfall is about 11 inches, the average annual temperature is 61° F., and the frost-free period is 200 to 230 days. The vegetation is mostly creosotebush, tobosa, snakeweed, and Russian-thistle. As much as 90 percent



Figure 11.—Area of Graham and House Mountain soils, 0 to 30 percent slopes.

of the area is barren. These soils are associated with Cornville, Glendale, Anthony, and Retriever soils.

In a representative profile the surface layer is light brownish-gray gravelly silty clay about 4 inches thick. The underlying layers are light brownish-gray silty clay or clay to a depth of 60 inches or more. The profile is strongly calcareous and moderately alkaline throughout.

Permeability is very slow. The available water capacity is 9 to 10 inches in the 60 inches or more of effective rooting depth.

Hantz soils are used chiefly as winter range. A few small areas are irrigated and used for crops.

Representative profile of Hantz gravelly silty clay, 0 to 5 percent slopes, in an area of range, SE $\frac{1}{4}$ sec. 4, T. 13 N., R. 5 E., Yavapai County:

A1—0 to 4 inches, light brownish-gray (10YR 6/2) gravelly silty clay, grayish brown (10YR 5/2) moist; weak, fine, platy structure parting to weak, medium, granular structure; slightly hard, friable, sticky and plastic; common fine and very fine roots; many very fine interstitial pores; 20 percent limestone gravel; violently effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

C1—4 to 14 inches, light brownish-gray (10YR 6/2) silty clay or clay, grayish brown (10YR 5/2) moist; massive; very hard, firm, sticky and plastic; few very fine and fine roots; common very fine and fine tubular and interstitial pores; common very fine and fine

limestone fragments; violently effervescent; moderately alkaline (pH 8.4); gradual, wavy boundary.

C2—14 to 66 inches, light brownish-gray (10YR 6/2) clay, light brownish-gray (10YR 6/2) moist; massive; very hard, firm, sticky and plastic; very few fine and very fine roots; common very fine tubular and interstitial pores; few fine and very fine limestone fragments; violently effervescent; moderately alkaline (pH 8.4).

The A horizon is gravelly silty clay or gravelly clay. The C horizon is heavy silty clay loam, silty clay, or clay. The profile is dominantly of 10YR hue, but is 7.5YR in places; value is 6 dry and 4 to 6 moist, and chroma is 2. Limestone gravel covers 20 to 25 percent of the surface area. In some small areas, structure is weakly expressed granular or blocky, and in others the horizons are massive. The profile is violently effervescent throughout; the calcium carbonate equivalent is 30 percent or greater.

Hantz gravelly silty clay, 0 to 5 percent slopes (HcB).—This soil is on alluvial fans in the Verde Valley and on bottom lands that are extensions of alluvial fans. In most places the surface is smooth and is covered with limestone gravel and fragments. In many places the soil is severely gullied.

About 5 percent of the acreage of this soil is an included Glendale loam and silt loam, and 10 percent is an included Guest clay, which is easily identified by its dark color. Also included are a few small hillocks of raw and partially weathered shale.

Runoff is medium. The erosion hazard is high.

This soil is in range herbage group 3, range improvement group 2, recreation group 4, and capability subclasses IIIe irrigated and VIIe dryland.

Hogg Series

The Hogg series consists of nearly level to moderately steep, well-drained soils that are 24 to 60 inches deep over bedrock. These soils formed in residuum weathered from cherty limestone and sandstone of the Kaibab Formation. They are on uplands, mostly on plateaus or mesas at elevations of 6,800 to 7,400 feet. Slopes are 0 to 20 percent. Annual rainfall is 18 to 22 inches, the average annual temperature is 44° F., and the frost-free period is 100 to 120 days. Vegetation is chiefly an open stand of ponderosa pine and an abundance of Gambel oak and alligator juniper. The understory is Arizona fescue, junegrass, squirreltail, blue grama, and pine dropseed. Buckwheat is the most common forb. These soils are associated with Brolliar, Jacks, McVickers, and Tortugas soils.

In a representative profile the surface layer is grayish-brown fine sandy loam about 3 inches thick. The subsoil extends to a depth of 52 inches. It is brown, reddish-brown, or dark reddish-brown clay loam or stony or gravelly clay. It is underlain by limestone bedrock. The profile is typically noncalcareous throughout, but in some places is slightly effervescent just above the limestone.

Permeability is slow. The available water capacity is 6 to 11 inches in the 24 to 60 inches of effective rooting depth.

Hogg soils are used for timber, wildlife, and summer range for livestock. They are a source of water for lower lying areas.

Representative profile of Hogg fine sandy loam, 0 to 20 percent slopes, in an area of cutover ponderosa pine, SW $\frac{1}{4}$ sec. 4, T. 14 N., R. 11 E., Coconino County:

A1—0 to 3 inches, grayish-brown (10YR 5/2) fine sandy loam, dark brown (10YR 3/3) moist; weak, coarse, platy structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; many fine and medium tubular pores and common micro and very fine interstitial pores; approximately 5 percent gravel; mildly alkaline (pH 7.4); abrupt, smooth boundary.

B21t—3 to 8 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) moist; moderate, fine, subangular blocky structure; very hard, firm, sticky and plastic; few very fine, fine, medium, and coarse roots; common micro and very fine interstitial pores and fine tubular pores; common moderately thick clay films on ped faces and in pores; mildly alkaline (pH 7.8); clear, smooth boundary.

B22t—8 to 20 inches, dark reddish-brown (5YR 3/4) clay, dark reddish brown (5YR 3/4) moist; moderate, medium and coarse, angular and subangular blocky structure; very hard, very firm, sticky and very plastic; very few fine, medium, and coarse roots; common micro and very fine interstitial pores and few fine tubular pores; many moderately thick clay films on ped faces and in pores; few stones; moderately alkaline (pH 8.0); clear, irregular boundary.

B23t—20 to 29 inches, dark reddish-brown (5YR 3/4) stony clay, yellowish red (5YR 4/6) moist; moderate, medium and coarse, subangular blocky structure; very hard, very firm, sticky and very plastic; very few fine and medium roots; few interstitial and fine tubular pores; many moderately thick clay films on

ped faces and in pores; approximately 20 percent stones; few limestone fragments are slightly effervescent; moderately alkaline (pH 8.0); clear, irregular boundary.

B24t—29 to 52 inches, reddish-brown (5YR 4/4) gravelly clay, reddish brown (5YR 4/4) moist; many, large, prominent, pinkish-white (7.5YR 8/2) mottles, reddish yellow (7.5YR 6/6) moist; weak, fine, prismatic structure parting to moderate, fine, angular blocky structure; hard, firm, sticky and very plastic; very few fine and medium roots; few micro and very fine interstitial pores; few moderately thick clay films on ped faces; approximately 15 percent gravel and 10 percent stones; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

R—52 inches, limestone bedrock.

The depth to bedrock is typically 30 to 55 inches, but ranges from 24 to 60 inches. Stones cover less than 3 percent of the surface area on the milder slopes, and 5 to 15 percent where slopes are more than 10 percent. Some profiles have an O1 horizon 1 to 3 inches thick. In some places the A horizon is fine sandy loam or loam and in other places it is gravelly or stony fine sandy loam or loam. It is of 10YR or 7.5YR hue; value is 4 or 5, and chroma is 2 or 3. The B horizon is clay loam, heavy clay loam to clay, or gravelly or stony clay. It is about 5 to 10 percent stones or cobblestones. It is dominantly of 5YR hue, but is 7.5YR in places; value is 3 to 5 dry and 2 or 3 moist, and chroma is 2 to 4 in the upper part and as much as 6 in the lower part.

Hogg fine sandy loam, 0 to 20 percent slopes (HgD).—This soil is on uplands on the Coconino Plateau. Slopes are 4 to 10 percent in about 60 percent of the mapped areas and 10 to 15 percent in about 30 percent.

About 5 to 10 percent of the acreage of this soil is an inclusion of McVickers soils and about 5 percent is an inclusion of very stony, hilly, shallow, slightly calcareous, dark-colored soils on narrow, convex ridges.

Runoff is medium. The erosion hazard is high.

This Hogg soil is in timber group 2b, range herbage group 2, range improvement group 1, recreation group 2a, and capability subclass VIe dryland.

Hogg Series, Calcareous Variant

The Hogg series, calcareous variant, consists of nearly level to sloping, well-drained soils that are more than 60 inches deep over bedrock. These soils formed in colluvium and alluvium weathered from calcareous shale and sandstone of the Moenkopi Formation. They are along foot slopes of Blue Ridge. Vegetation is ponderosa pine, Gambel oak, and alligator juniper. The understory is mountain muhly, pine dropseed, squirreltail, and junegrass. These soils are associated with Hogg, Chilson, and Brolliar soils.

In a representative profile the surface layer is reddish-brown loam about 4 inches thick. The subsoil is mainly reddish-brown clay to a depth of 42 inches. The substratum is reddish-brown clay loam to a depth of 60 inches or more.

Permeability is slow. The available water capacity is 8 to 12 inches in the 60 or more inches of effective rooting depth.

These soils are used for timber, range, and wildlife.

Representative profile of Hogg loam, calcareous variant, 0 to 10 percent slopes, in an area of ponderosa pine, Gambel oak, and alligator juniper, NE $\frac{1}{2}$ sec. 17, T. 14 N., R. 11 E., Coconino County:

A1—0 to 4 inches, reddish-brown (5YR 5/3) loam, dark reddish brown (5YR 3/2) moist; moderate, medium and coarse, platy structure parting to moderate, medium, granular structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and fine roots; many micro and very fine interstitial pores; approximately 5 percent gravel; mildly alkaline (pH 7.6); clear, smooth boundary.

B21t—4 to 12 inches, reddish-brown (2.5YR 4/4) light clay or heavy clay loam, dark reddish brown (2.5YR 2/4) moist; moderate, fine, angular and subangular blocky structure; hard, friable, slightly sticky and plastic; many fine, medium, and coarse roots; many micro and very fine interstitial pores and common very fine and fine tubular pores; common thin clay films on ped faces and in pores; approximately 5 percent gravel; mildly alkaline (pH 7.8); clear, wavy boundary.

B22t—12 to 31 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; moderate, fine and medium, prismatic structure parting to strong, medium, angular and subangular blocky structure; very hard, firm, sticky and very plastic; few fine and medium roots and many coarse roots; many micro and very fine interstitial pores and common very fine and fine tubular pores; many thin clay films on ped faces and in pores; few pebbles; few fine manganese concretions; mildly alkaline (pH 7.8); clear, wavy boundary.

B23t—31 to 42 inches, reddish-brown (2.5YR 4/4) light clay, dark reddish brown (2.5YR 3/4) moist; common, medium, distinct, pink (7.5YR 7/4) lime filaments and segregations; moderate, medium and coarse, angular and subangular blocky structure; very hard, friable, sticky and very plastic; few fine, medium, and coarse roots; many micro and very fine interstitial pores and many very fine and fine tubular pores; many thin clay films on ped faces; few pebbles; common fine manganese concretions; typically slightly effervescent, but strongly effervescent in places; moderately alkaline (pH 8.2); clear, wavy boundary.

Cca—42 to 64 inches, reddish-brown (2.5YR 5/4) clay loam, dark reddish brown (2.5YR 3/4) moist; common, medium, distinct, pinkish-white (7.5YR 8/2) lime filaments and segregations; massive; hard, friable, slightly sticky and plastic; few fine, medium, and coarse roots; many micro and very fine interstitial pores and fine and medium tubular pores; approximately 5 percent gravel; common fine manganese concretions; strongly effervescent; moderately alkaline (pH 8.2).

The A horizon ranges from fine sandy loam to clay loam. The B horizon is of 5YR and 2.5YR hue. The depth to lime accumulation ranges from 15 to 42 inches.

Hogg loam, calcareous variant, 0 to 10 percent slopes (H1C).—This soil is in colluvial and alluvial material along the base of Blue Ridge. Slopes are dominantly 2 to 5 percent.

Inclusions of Chilson and Broliar soils make up about 5 percent of the total acreage of this soil.

Runoff is slow. The erosion hazard is moderate.

This Hogg soil is in timber group 2a, range herbage group 2, range improvement group 1, recreation group 2a, and capability subclass VIe dryland.

House Mountain Series

The House Mountain series consists of gently sloping to moderately steep, well-drained soils that are 4 to 14 inches deep over bedrock. These soils formed in residuum weathered from basalt. They are on uplands. Slopes range from 0 to 60 percent. Elevation ranges from 3,000

to 4,000 feet. Annual rainfall is between 11 and 13 inches, the average annual temperature is 61° F., and the frost-free period is 200 to 230 days. The vegetation is mesquite, snakeweed, yucca, pricklypear, cholla, filaree, tobosa, side-oats grama, and bush muhly. About 50 percent of the area of these soils is barren. House Mountain soils are associated with Bridge, Graham, and Retriever soils.

In a representative profile the surface layer is brown stony loam about 2 inches thick. The underlying layer is brown gravelly loam. Basalt is at a depth of 8 inches. The profile is noncalcareous and mildly alkaline throughout.

Permeability is moderate. The available water capacity is 2 to 3 inches in the 4 to 14 inches of effective rooting depth.

House Mountain soils are used for winter livestock range and wildlife.

Representative profile of House Mountain stony loam in an area of range, NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 5, T. 13 N., R. 6 E., Yavapai County:

A1—0 to 2 inches, brown (7.5YR 4/2) stony loam, dark brown (7.5YR 3/2) moist; single grain; loose dry or moist, slightly sticky and plastic; very few fine roots; common micro and very fine interstitial pores; 30 percent gravel and stones; mildly alkaline (pH 7.6); clear, smooth boundary.

C—2 to 8 inches, brown (7.5YR 4/2) gravelly heavy loam, dark brown (7.5YR 3/2) moist; massive parting to weak, fine, subangular blocky structure; soft, friable, slightly sticky and plastic; very few very fine and fine roots; common micro and very fine interstitial pores and few fine tubular pores; 20 percent gravel; mildly alkaline (pH 7.6); abrupt, irregular boundary.

R—8 inches, very dark gray (10YR 3/1), fractured basalt bedrock.

The A horizon is stony loam, gravelly loam, or gravelly sandy loam. It is dominantly of 7.5YR hue, but is 10YR in places; value is 4 to 5 dry, and chroma is 2 to 4. The C horizon is gravelly loam, gravelly heavy loam, or gravelly light clay loam. It ranges from 10YR to 5YR hue, but is dominantly 7.5YR. The C horizon is cobbly or stony in some profiles. Most House Mountain soils are noneffervescent, but the soils that formed in residuum of calcareous basalt or basalt that contained calcareous concretions are effervescent throughout the profile.

House Mountain stony loam, 0 to 30 percent slopes (HmD).—This soil is on uplands in the basalt area below the Mogollon Rim. Slopes are dominantly 10 to 20 percent. Basalt stone covers 10 to 25 percent of the surface, gravel covers 20 to 35 percent, and there is some basalt outcrop.

Included with this soil in mapping are small areas of Graham soils; areas of soils similar to the House Mountain soil, but underlain by tuff; and small, scattered areas of reddish soils near cinder deposits.

Runoff is medium to rapid. The erosion hazard is moderate.

This House Mountain soil is in range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIe dryland.

Jacks Series

The Jacks series consists of nearly level to very steep, well-drained soils that are 20 to 50 inches deep over bedrock. These soils formed in residuum weathered from sandstone and some limestone. They are on uplands

dissected by numerous shallow drains. Slopes range from 0 to 45 percent. Elevation ranges from 6,400 to 6,900 feet. Annual rainfall ranges from 15 to 18 inches, the average annual temperature is 48° to 54° F., and the frost-free period is 130 to 160 days. These soils support the chaparral, pinyon-juniper, and ponderosa pine vegetation types. The dominant species are ponderosa pine, shrub live oak, Gambel oak, alligator juniper, cliffrose, blue grama, junegrass, squirreltail, pine dropsed, and fringed sagebrush. These soils are associated with McVickers and Wildcat soils at the higher elevations and with Dye, Lynx, Tortugas, and Winona soils at the lower elevations.

In a representative profile the surface layer is reddish-brown fine sandy loam about 3 inches thick. The subsoil is mainly yellowish-red clay and very stony clay. Calcareous sandstone is at a depth of about 42 inches. The profile is noncalcareous throughout and is mildly or moderately alkaline.

Permeability is slow. The available water capacity is 5 to 7 inches in the 20 to 50 inches of effective rooting depth.

Jacks soils are used for timber, livestock, and wildlife.

Representative profile of Jacks fine sandy loam, 0 to 20 percent slopes, in an area of cutover ponderosa pine, SW $\frac{1}{4}$ sec. 32, T. 15 N., R. 12 E., Coconino County:

O1—3 to 2 inches, fresh pine needles; noneffervescent; neutral (pH 6.6).

O2—2 inches to 0, decomposing pine needles; noneffervescent; neutral (pH 6.8).

A1—0 to 3 inches, reddish-brown (5YR 5/3) light fine sandy loam, dark reddish brown (5YR 3/4) moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine and fine roots; many micro and very fine interstitial pores and common fine tubular pores; approximately 5 percent gravel and cobblestones; mildly alkaline (pH 7.4); abrupt, wavy boundary.

B1—3 to 7 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) moist; weak, medium, subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; many micro and very fine interstitial pores and common very fine and fine tubular pores; few thin clay films on ped faces and as bridges; approximately 10 percent stones; mildly alkaline (pH 7.6); clear, smooth boundary.

B21t—7 to 27 inches, yellowish-red (5YR 4/6) clay, yellowish red (5YR 4/6) moist; weak, medium, prismatic structure parting to strong, medium, angular blocky structure; very hard, very firm, sticky and very plastic; few fine, medium, and coarse roots; common micro and very fine interstitial pores and common very fine tubular pores; many moderately thick films on ped faces and in pores; approximately 5 percent gravel and 10 percent stones; moderately alkaline (pH 8.0); clear, wavy boundary.

B22t—27 to 42 inches, yellowish-red (5YR 4/6) very stony clay, yellowish red (5YR 4/8) moist; weak, medium and fine, angular blocky structure; very hard, very firm, sticky and very plastic; very few fine, medium, and coarse roots; common micro and very fine interstitial pores and common very fine tubular pores; many moderately thick clay films on ped faces; approximately 50 percent calcareous weathered sandstone; moderately alkaline (pH 8.2); clear, wavy boundary.

R—42 inches, calcareous, slightly weathered sandstone.

Most profiles have a layer of litter on the surface. The A horizon is light fine sandy loam or very fine sandy loam. It is of 10YR to 5YR hue; value is 4 or 5 dry and 3 or 4 moist,

and chroma is 4 to 6. The B1 horizon is sandy clay loam, clay loam, or heavy loam 3 to 6 inches thick. It is of 7.5YR or 5YR hue; value is 4 or 5, and chroma is 4 to 6. Some profiles lack a B1 horizon. The B2t horizon ranges from heavy clay loam to clay and very stony clay. It is of 5YR and 2.5YR hue. The depth to bedrock is commonly 30 to 40 inches, but ranges from 20 to 50 inches. Most profiles are noneffervescent. Some are slightly calcareous in the lower part of the subsoil.

Jacks fine sandy loam, 0 to 20 percent slopes (JaD).—This soil is on uplands that are dissected by many shallow drainageways. Slopes are dominantly less than 10 percent. This soil has the profile described as representative of the series.

Included areas of soils similar to the Jacks soil but less than 20 inches deep over bedrock make up 5 percent of the acreage of this soil, and included areas of Tortugas soils make up 5 percent. Also included are small areas of Wildcat soils at the higher elevations and some areas of Lynx soils along drainageways.

Runoff is medium. The erosion hazard is moderate. Small gullies and rills have formed.

This Jacks soil is in timber group 3, range herbage group 3, range improvement group 2, recreation group 2a, and capability subclass VIe dryland.

Jacks-Tortugas extremely rocky complex, 0 to 20 percent slopes (JtD).—This complex is about 35 percent Jacks fine sandy loam, about 25 percent Tortugas very stony loam, and about 30 percent sandstone and limestone outcrop (fig. 12). The Jacks soil and the sandstone rock outcrop are on north- and east-facing slopes along drainageways, and the Tortugas soil and limestone outcrop are on the south- and west-facing slopes.

Included areas of Hogg soils make up about 5 percent of the total acreage of this soil, and included areas of noneffervescent sandy loam over limestone make up 5 percent. Also included are minor areas of McVickers soils and areas of Lynx soils on the bottoms of drainageways.

These soils are in timber group 3, range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIs dryland.

Jacks-Tortugas extremely rocky complex, 20 to 45 percent slopes (JtE).—This complex is similar to Jacks-Tortugas extremely rocky complex, 0 to 20 percent slopes, but a larger number of rock outcrop, cobblestones, and stones are on the surface.

These soils are in timber group 3, range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIs dryland.

Limestone and Sandstone Rock Land

Limestone and sandstone rock land (Ls) consists of two distinct steep to very steep landforms at elevations of 6,200 to 7,800 feet. Precipitation ranges from 15 inches at the lower elevations to 24 inches at the higher elevations.

One landform is about 65 to 75 percent rock outcrop and 25 to 35 percent soil. The landscape is one of numerous vertical or nearly vertical exposures of the Coconino and Kaibab Formations; steep and very steep sides of draws, deeply incised canyons, and sand and gravelly benches at the bottoms of the deeper, wider canyons, all at the lower elevations; and very short, but steep slopes



Figure 12.—Open stand of ponderosa pine on Jacks-Tortugas extremely rocky complex.

along the heads of draws at the higher elevations (fig. 13). The slope gradient ranges from 40 to 80 percent, but it is commonly 60 to 70 percent.

The soils that are shallow over bedrock resemble Tortugas soils, are at elevations below 6,900 feet, and are commonly calcareous. Some of the soils in pockets at the higher elevations have a weakly expressed subsoil and are noncalcareous.

Vegetation varies, depending on the elevation and the exposure. The higher elevations and canyon bottoms support Douglas-fir, white fir, and ponderosa pine. All three species grow near the bottoms of the slopes and are of good quality. Quality and growth become poorer with increasing elevation up the canyon walls. At the lower elevations pinyon pine, juniper, cliffrose, algerita, skunk-bush sumac, blue grama, and side-oats grama are the chief species. Vegetation is denser on north-facing slopes than on south-facing slopes.

The other landform is characterized by very steep slopes of more than 80 percent and precipitous cliffs of Coconino and Supai Sandstone capped with Kaibab Limestone. The extremely steep part forms the spectacular, nearly vertical varicolored walls of East and West Clear Creek Gorges, and the lower reaches of Barbershop Canyon, Bear Canyon, Houston Draw, Jacks Canyon, and Leonard Canyon.

Where the steep slopes and cliffs have a definite north aspect, some pockets of soil support ponderosa pine and scattered patches of brush. The cool, sheltered places on benches support a few Douglas-fir.

About 1,000 acres of cliffs of the Verde Formation in the Verde Valley part of the survey area is included in the areas mapped. Vegetation is sparse and is growing in pockets of soil similar to Retriever soils. The most common species are canotia, creosotebush, and prickly-pear.

Limestone and sandstone rock land is unsuitable for range and timber. Timber cannot be harvested by conventional logging methods. The spectacular cliffs have scenic appeal. They provide a natural firebreak, but a barrier to common means of overland travel. The hydrologic characteristics are such that large volumes of runoff are produced during snowmelt and intense summer storms.

This rock land is in recreation group 5b and capability subclass VIIIs dryland.

Luth Series

The Luth series consists of nearly level to gently sloping, well-drained soils that are more than 60 inches deep over bedrock. These soils formed in alluvium weathered



Figure 13.—Walls of limestone and sandstone rock land in East Clear Creek Canyon.

mainly from basalt and partly from limestone and sandstone. Slopes range from 0 to 5 percent. The climate is subhumid. Annual precipitation is 18 to 23 inches, the average annual temperature is 45° F., and the frost-free period is 10 to 110 days. Elevation ranges from 6,700 to 7,250 feet. The vegetation is blue grama, pine dropsseed, timothy, wolftail, western wheatgrass, iris, yarrow, pussytoes, and vetch. These soils are associated with Broliar, Friana, Hogg, McVickers, and Overgaard soils.

In a representative profile the surface layer is brown clay loam about 5 inches thick. The underlying layers are brown or dark grayish-brown clay loam to a depth of more than 60 inches. The profile is noneffervescent and mildly alkaline throughout.

Permeability is slow. The available water capacity is 8 to 12 inches in the 60 inches or more of effective rooting depth.

Luth soils are used for wildlife and for summer and fall livestock range.

Representative profile of Luth clay loam, 0 to 5 percent slopes, in a grass-covered drainageway, SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 35, T. 15 N., R. 9 E., Coconino County:

A1—0 to 5 inches, brown (10YR 5/3) light clay loam, dark brown (10YR 3/3) moist; moderate, medium, granular structure; soft, friable, sticky and slightly plastic; common very fine and fine roots; many micro

and very fine interstitial pores; moderately alkaline (pH 8.0); clear, smooth boundary.

C1—5 to 13 inches, brown (10YR 4/3) heavy clay loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, sticky and plastic; few very fine and fine roots; common fine and medium tubular pores and common very fine interstitial pores; common fine pressure faces; mildly alkaline (pH 7.8); clear, smooth boundary.

C2—13 to 33 inches, dark grayish-brown (10YR 4/2) heavy clay loam, very dark brown (10YR 2/2) moist; massive; hard, friable, sticky and plastic; few very fine and fine roots; common fine and medium tubular pores and common very fine interstitial pores; mildly alkaline (pH 7.8); gradual, smooth boundary.

C3—33 to 53 inches, dark grayish-brown (10YR 4/2) heavy clay loam, very dark brown (10YR 2/2) moist; massive; slightly hard, friable, sticky and slightly plastic; very few very fine, fine, and medium roots; common very fine and fine tubular pores and many very fine interstitial pores; many pressure faces; mildly alkaline (pH 7.8); abrupt, smooth boundary.

C4—53 to 60 inches, brown (10YR 5/3) heavy clay loam, dark brown (10YR 3/3) moist; massive; slightly hard, friable, sticky and slightly plastic; very few very fine, fine, and medium roots; common very fine and fine tubular pores and many very fine interstitial pores; approximately 10 percent gravel; mildly alkaline (pH 7.4).

The A1 horizon is clay loam in most profiles, but is loam in some. It is dominantly of 10YR hue, but is 7.5YR in places; value is 3 to 5 dry and 2 to 3 moist, and chroma is 1 to 3.

The C horizon is heavy clay loam or clay and is gravelly in some profiles. It is of 10YR to 5YR hue; value is 2 to 5 dry and 2 or 3 moist. Chroma is mostly 2 or 3, but is 5 or 6 in the deepest part of some C horizons.

Luth clay loam, 0 to 5 percent slopes (LuB).—This soil is in drainageways (fig. 14) and on alluvial flood plains in the ponderosa pine forest. Slopes are commonly 1 to 2 percent in the central part of the drainageways, but increase near the edges and heads. Relief is concave.

Inclusions of Clover Springs soils make up 5 percent of the areas.

Active gullies are cutting most areas of this Luth soil.

This soil is in range herbage group 1, range improvement group 1, recreation group 1c, and capability subclass VIe dryland.

Lynx Series

The Lynx series consists of nearly level to gently sloping, well-drained soils that formed in mixed alluvium on flood plains and bottom land. Slopes range from 0 to 5 percent. Elevation ranges from 6,200 to 6,700 feet. Annual rainfall is 13 to 16 inches, the average annual temperature ranges from 52° to 59° F., and the frost-free period is 160 to 200 days. These soils are mostly in the pinyon-juniper woodland. The understory is chiefly blue

grama, sand dropseed, snakeweed, rabbitbrush, and various annuals. About 50 percent of the area is barren. These soils are associated with Dye, Jacks, Tortugas, and Winona soils.

In a representative profile the surface layer is brown fine sandy loam about 8 inches thick. The underlying layers are brown to dark-brown clay loam and fine sandy loam to a depth of 60 inches or more. Some profiles are stratified. These soils are noncalcareous in the upper part of the profile and slightly calcareous in the lower part. They are mildly alkaline throughout.

Permeability is moderately slow. The available water capacity is 7 to 12 inches in the 40 inches or more of effective rooting depth.

Lynx soils are used as livestock and wildlife range.

Representative profile of Lynx fine sandy loam, 0 to 5 percent slopes, in a grass-covered drainageway, SE $\frac{1}{4}$ sec. 4, T. 15 N., R. 12 E., Coconino County:

A1—0 to 8 inches, brown (7.5YR 4/2) fine sandy loam, dark brown (7.5YR 3/2) moist; moderate, fine, granular structure and moderate, fine, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine roots; many very fine and fine interstitial pores; a few pebbles; mildly alkaline (pH 7.8); clear, smooth boundary.



Figure 14.—Luth clay loam. This small drainageway is near Lost Eden.

C1—8 to 41 inches, brown (7.5YR 4/2) light clay loam, dark brown (7.5YR 3/2) moist; massive; slightly hard, friable, slightly sticky and plastic; few very fine, fine, and medium roots; many very fine, fine, and medium tubular pores and many fine interstitial pores; few large krotovinas; mildly alkaline (pH 7.8); clear, wavy boundary.

C2—41 to 60 inches, dark-brown (7.5YR 3/2) fine sandy loam, dark reddish brown (5YR 3/2) moist; massive structure parting to weak, coarse, subangular blocky structure; slightly hard, very friable, slightly sticky and slightly plastic; many fine interstitial pores and few fine tubular pores; very slightly effervescent; moderately alkaline (pH 8.2).

The A horizon is dominantly fine sandy loam, but is loam in places. In some profiles it is gravelly. The C1 horizon ranges from heavy loam to light clay loam. In some profiles it is thinly stratified with gravel. Both the A and C horizons are of 7.5YR hue; value is 3 to 5 dry and 2 or 3 moist, and chroma is 2 or 3. Organic-matter content is about 2 percent in the thick surface layer and is less than 1 percent in the underlying layers.

Lynx fine sandy loam, 0 to 5 percent slopes (LyB).—This soil is on flood plains and bottom land. It is chiefly in the northeastern part of the survey area.

Strongly effervescent, reddish soils, chiefly in the alluvial areas adjacent to Red Hill, make up about 20 percent of the acreage of this soil. They resemble the soils of the Tours series, as mapped in the West Yavapai County Area. Also included in mapping are small areas of dark-brown soils that are light loam or sandy loam just below the surface layer.

Runoff is slow. The erosion hazard is high.

This Lynx soil is in range herbage group 2, range improvement group 3, recreation group 1c, and capability subclass VIe dryland.

McVickers Series

The McVickers series consists of nearly level to moderately steep, well-drained soils that are 30 to 60 inches deep over bedrock. These soils formed in residuum weathered from sandstone. They are on uplands. The slope gradient is 0 to 30 percent. The elevation ranges from 6,800 to 7,500 feet. Annual rainfall is 20 to 25 inches, the average annual temperature is 43° to 47° F., and the frost-free period is 80 to 100 days. The overstory is a somewhat dense stand of ponderosa pine and some Gambel oak and alligator juniper. The understory is Arizona fescue, mountain mully, pine dropsseed, squirreltail, forbs, and Fendler ceanothus. These soils are associated with Clover Springs, Hogg, Soldier, and Wildcat soils.

In a representative profile the surface layer is brown very fine sandy loam about 2 inches thick. The subsurface layers are pale-brown very fine sandy loam and pinkish-gray cobbly very fine sandy loam about 12 inches thick. The subsoil is mainly yellowish-red clay that extends to a depth of 33 inches. Below this is a mixture of yellowish-red and reddish-yellow clay mixed with sandstone. Extremely hard sandstone bedrock is at a depth of about 45 inches. The profile is noncalcareous throughout; it is medium to slightly acid.

Permeability is slow. The available water capacity is 6 to 11 inches in the 30 to 60 inches of effective rooting depth.

McVickers soils are used for timber, range, water

Representative profile of McVickers very fine sandy loam, 0 to 10 percent slopes, in an area of ponderosa pine, SW $\frac{1}{4}$ sec. 24, T. 14 N., R. 9 E., Coconino County:

O1 & O2—1 inch to 0, decomposed and partially decomposed pine needles, twigs, and grasses; strongly acid (pH 5.5), 0 to 2 inches thick.

A1—0 to 2 inches, brown (10YR 5/3) very fine sandy loam, dark brown (10YR 4/3) moist; weak, fine, granular structure; slightly hard, very friable, nonsticky and nonplastic; common very fine and fine roots; many micro and very fine interstitial pores; few to common cobblestones and pebbles; neutral (pH 6.6); abrupt, smooth boundary.

A21—2 to 6 inches, pale-brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) moist; weak, medium and coarse, platy structure; slightly hard, very friable, nonsticky and nonplastic; common fine and medium roots; few fine tubular pores and many fine interstitial pores; common fine pebbles; medium acid (pH 6.0); clear, smooth boundary.

A22—6 to 14 inches, pinkish-gray (7.5YR 7/2) cobbly very fine sandy loam, brown (7.5YR 5/4) moist; massive; hard, friable, nonsticky and nonplastic; common fine and medium roots; common fine and few medium and fine tubular pores and many fine interstitial pores; medium acid (pH 6.0); abrupt, irregular boundary.

B1—14 to 16 inches, reddish-brown (5YR 5/4) loam, reddish brown (5YR 4/4) moist; moderate, fine and medium, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine and medium roots; few fine tubular pores and many fine interstitial pores; tongues from the A2 horizon; common fine pebbles; slightly acid (pH 6.5); abrupt, broken boundary.

B21t—16 to 26 inches, yellowish-red (5YR 5/6) clay, yellowish red (5YR 5/6) moist; few, fine, weathered reddish-yellow (7.5YR 7/6) sandstone fragments, reddish yellow (7.5YR 6/6) moist; strong, fine, medium and coarse, angular blocky structure; very hard, firm, sticky and very plastic; common fine and medium roots, few coarse and very coarse roots; common fine tubular pores and few fine interstitial pores; continuous clay films on ped faces; common small slickensides; tongues from A2 horizon; few to common pebbles; slightly acid (pH 6.5); gradual, irregular boundary.

B22t—26 to 33 inches, yellowish-red (5YR 5/6) clay, yellowish red moist; many, distinct, medium and coarse, reddish-yellow (7.5YR 7/8) mottles, reddish yellow (7.5YR 7/8) moist; strong, medium and coarse, angular blocky structure; very hard, firm, sticky and very plastic; few fine roots; few fine tubular pores and common fine interstitial pores; continuous thin clay films; common small slickensides; mottles are weathered, angular sandstone fragments; slightly acid (pH 6.5); gradual, irregular boundary.

C & B3—33 to 45 inches, mixture of sandstone and yellowish-red (5YR 5/6) and reddish-yellow (7.5YR 7/8) clay; 50 to 70 percent sandstone; massive; very hard, firm, sticky and plastic; few fine and medium roots; few moderately thick clay films; slightly acid (pH 6.5); abrupt, irregular boundary.

R—45 inches, extremely hard sandstone bedrock.

The A1 horizon is fine sandy loam or very fine sandy loam. It is of 10YR hue; value is 3 or 4 moist, and chroma is 2 or 3. In places there is no A1 horizon. The A2 horizon is very fine sandy loam, fine sandy loam, or loam, and is cobbly in places. The B2t horizon is heavy clay loam or clay, and has strong, prismatic or subangular blocky structure. The depth to sandstone is typically 30 to 60 inches. Coarse fragments range from 10 percent of the soil mass in the upper part of the profile to 50 percent in the lower part.

McVickers very fine sandy loam, 0 to 10 percent slopes (McC).—This soil is on sandstone uplands on the Coconino Plateau in the southern and east-central parts of the sur-



Figure 15.—Stand of ponderosa pine on McVickers very fine sandy loam.

sentative of the McVickers series. Slopes range from 0 to 10 percent, but are dominantly 5 percent. Generally, less than 5 percent of the surface area is covered with stones. In a few places this soil is as much as 25 percent fine gravel.

Included with this soil in mapping are areas of Hogg soils, which make up about 5 percent of the total acreage; areas of Clover Springs and Luth soils in drainageways; a few areas where bedrock is at a depth of more than 60 inches, and a few where it is within a depth of 20 inches; areas of soils, in depressions and swales, that have a surface layer 20 to 36 inches thick, but are otherwise similar to McVickers soils; and some short, abrupt slopes, near many of the drainageways, that are 40 to 60 percent stones and rock outcrop.

Runoff is slow to medium. The erosion hazard is slight to moderate.

This McVickers soil is in timber group 2a, range herbage group 2, range improvement group 1, recreation group 1a, and capability subclass VIe dryland.

McVickers-Hogg complex, 0 to 10 percent slopes (MhC).—This mapping unit is about 50 percent McVickers very fine sandy loam and 35 percent Hogg fine sandy loam. For the most part, these soils are intermingled, but in local areas the McVickers soil is on nearly smooth

terrain and the Hogg soil is on small knolls and narrow ridges.

Inclusions of limestone and sandstone outcrop make up about 10 percent of the total acreage, and an unnamed, shallow, slightly calcareous loam and Wildcat soils account for about 5 percent.

These McVickers and Hogg soils are in timber group 2a, range herbage group 2, range improvement group 1, recreation group 1a, and capability subclass VIe dryland.

McVickers-Hogg complex, 10 to 30 percent slopes (MhD).—This mapping unit is about 45 percent McVickers very fine sandy loam, 30 percent Hogg fine sandy loam, and 20 percent limestone and sandstone outcrop.

Included with these soils in mapping are small areas of an unnamed, slightly calcareous loam; areas of Wildcat soils; areas of Clover Springs soils along drainageways; and local areas of stony McVickers and Hogg soils.

These McVickers and Hogg soils are in timber group 2a, range herbage group 2, range improvement group 2, recreation group 1b, and capability subclass VIe dryland.

Navajo Series

The Navajo series consists of nearly level to gently sloping, well-drained soils that formed in recent alluvium derived from sandstone, limestone, shale, and basalt.

These soils are in drainageways and swales. Slopes range from 0 to 5 percent. Elevation ranges from 6,000 to 6,400 feet. Annual rainfall is 12 to 15 inches, the average annual temperature is 52° to 58° F., and the frost-free period is 160 to 200 days. Vegetation is chiefly blue grama, squirreltail, sand dropseed, western wheatgrass, snake-weed, and Russian-thistle. These soils are associated with Disterheff, Tortugas, and Winona soils.

In a representative profile the surface layer is reddish-brown silty clay about 5 inches thick. The underlying layers are reddish-brown silty clay and clay to a depth of 60 inches or more. The profile is moderately alkaline and calcareous throughout.

Permeability is very slow. The available water capacity is 8 to 11 inches in the 60 inches or more of effective rooting depth.

Navajo soils are used for livestock range and wildlife.

Representative profile of Navajo silty clay, 0 to 5 percent slopes, in a drainageway, SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 1, T. 16 N., R. 11 E., Coconino County:

A1—0 to 5 inches, reddish-brown (5YR 5/4) light silty clay, dark reddish brown (5YR 3/4) moist; moderate, fine, granular structure; hard, friable, sticky and slightly plastic; very few very fine roots; many micro and very fine interstitial pores; violently effervescent; moderately alkaline (pH 8.4); clear, wavy boundary.

C1—5 to 12 inches, reddish-brown (5YR 5/4) silty clay, dark reddish brown (5YR 3/4) moist; massive; hard, friable, sticky and plastic; few very fine and fine roots; common fine tubular pores and many micro and very fine interstitial pores; common pressure faces; violently effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

C2—12 to 72 inches, reddish-brown (5YR 5/4) clay, dark reddish brown (5YR 3/4) moist; massive; very hard, friable, sticky and plastic; few very fine roots; common fine tubular pores and many micro and very fine interstitial pores; common pressure faces; violently effervescent; moderately alkaline (pH 8.4).

The A horizon is dominantly silty clay, but in places is light clay loam, light silty clay, or clay. The C horizon is mostly silty clay or clay, but is clay loam in places. The A and C horizons are chiefly of 5YR hue, but in places are 2.5YR; value is 4 or 5 dry and 3 or 4 moist, and chroma is 3 or 4. There are a few gravelly spots on the surface, and some profiles have gravelly material below a depth of 30 inches. In some profiles shale or sandstone is within a depth of 40 inches.

Navajo silty clay, 0 to 5 percent slopes (NcB).—This soil is on the Coconino Plateau in drainageways and swales, chiefly in the north-central part of the survey area. It formed over shale and sandstone of the Moenkopi Formation. Slope gradients are dominantly 2 percent, but are about 5 percent along the outer edges of draws and swales.

Included areas of Disterheff, Tortugas, and Winona soils make up about 15 percent of the total acreage of this soil.

Runoff is medium. The erosion hazard is moderate, and some areas of this Navajo soil are gullied.

This Navajo soil is in range herbage group 2, range improvement group 2, recreation group 4, and capability subclass VIc dryland.

Overgaard Series

The Overgaard series consists of nearly level to hilly, well-drained soils that formed in gravelly old alluvium

and colluvium. These soils are on uplands in the ponderosa pine forest. Slopes range from 0 to 20 percent. Elevation ranges from 6,800 to 7,200 feet. Annual rainfall is 20 to 22 inches, the average annual temperature ranges from 44° to 47° F., and the frost-free period is 80 to 100 days. The vegetation is a vigorous stand of ponderosa pine, some Gambel oak, and an understory of Arizona fescue, pine dropseed, junegrass, and mountain muhly. These soils are associated with Broliar, Clover Springs, Hogg, Luth, and McVickers soils.

In a representative profile the surface layer is grayish-brown sandy loam about 2 inches thick. The subsurface layer is light brownish-gray gravelly sandy loam about 8 inches thick. The subsoil is reddish-brown gravelly clay and gravelly clay loam to a depth of 60 inches. The substratum is reddish-brown gravelly clay loam.

Permeability is slow. The available water capacity is 9 to 12 inches in the 60 inches or more of effective rooting depth.

Overgaard soils are used for timber, range, and wildlife.

Representative profile of Overgaard sandy loam, 0 to 20 percent slopes, in an area of ponderosa pine, NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 33, T. 14 N., R. 9 E., Coconino County:

O1—1 inch to 0, pine needles and twigs; very strongly acid (pH 5.0).

A1—0 to 2 inches, grayish-brown (10YR 5/2) sandy loam, dark grayish brown (10YR 4/2) moist; weak, coarse, platy structure parting to weak, fine, granular structure; slightly hard, friable, nonsticky and nonplastic; few fine roots; many very fine interstitial pores and few very fine tubular pores; neutral (pH 6.6); abrupt, smooth boundary.

A2—2 to 10 inches, light brownish-gray (10YR 6/2) gravelly sandy loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, nonsticky and nonplastic; few fine and medium roots; common very fine interstitial pores; 20 percent gravel; neutral (pH 6.6); abrupt, smooth boundary.

B21t—10 to 25 inches, reddish-brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate, medium and coarse, angular blocky structure; very hard, firm, sticky and very plastic; common very fine roots and few fine and medium roots; few micro tubular pores; continuous clay films on ped faces; common dark organic stains on ped faces; 30 percent fine gravel; neutral (pH 6.8); clear, irregular boundary.

B22t—25 to 38 inches, reddish-brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate, medium and coarse, angular blocky structure; very hard, firm, sticky and very plastic; common very fine roots and few fine roots; few micro tubular pores; continuous clay films on ped faces; many dark organic stains and coatings on ped faces; 25 percent fine gravel; neutral (pH 7.0); gradual, irregular boundary.

B23t—38 to 60 inches, reddish-brown (5YR 4/4) gravelly clay loam, dark reddish brown (5YR 3/4) moist; many, coarse, distinct, reddish-yellow (7.5YR 6/8) mottles; common, medium, prominent, black (5YR 2/1) manganese coatings on peds; moderate, medium and coarse, subangular and angular blocky structure; hard to very hard, friable, sticky and plastic; few fine roots; very few micro tubular pores; clay films on ped faces; 20 percent fine to coarse gravel; neutral (pH 7.2); gradual, wavy boundary.

C—60 to 66 inches, reddish-brown (5YR 4/4) gravelly clay loam, dark reddish brown (5YR 3/4) moist; massive; hard, friable, sticky and plastic; 30 percent gravel; very slightly effervescent in spots; mildly alkaline (pH 7.4).

The A horizon is chiefly sandy loam, but is gravelly sandy loam, fine sandy loam, or loamy fine sand in some profiles. It is of 10YR hue; value is 4 to 6 dry and 4 moist, and chroma is 2. The B horizon is gravelly or cobbly clay. It is 15 to 40 percent gravel and up to 15 percent cobblestones. It is dominantly of 5YR hue, but is 7.5YR in places; value is 4 or 5 dry and 3 or 4 moist.

Overgaard sandy loam, 0 to 20 percent slopes (OvD).—This soil is on uplands. It formed in old alluvium derived from sandstone, quartzite, rhyolite, granite, and chert. Slopes are dominantly less than 10 percent. Gravel covers 5 to 15 percent of the surface area. There are a few cobblestones and stones.

Included areas of Luth and Clover Springs soils in drainageways make up about 5 percent of the total acreage of this soil, and Hogg soils, McVickers soils, and Limestone and sandstone rock land about 5 to 10 percent. Also included are small areas of Broliar soils and small areas where slopes are more than 20 percent and the soil is only 3 feet deep over sandstone.

Runoff is slow. The erosion hazard is moderate. Surface erosion is none to slight on most of this Overgaard soil, but some drainageways are gullied.

This Overgaard soil is in timber group 2a, range herbage group 3, range improvement group 1, recreation group 1a, and capability subclass VIc dryland.

Palomino Series

The Palomino series consists of gently sloping to strongly sloping, well-drained soils that are 12 to 20 inches deep over bedrock. These soils are on uplands of the Coconino Plateau. They formed in residuum weathered from sandstone. Slopes range from 0 to 15 percent. Elevation ranges from 7,200 to 7,800 feet. Annual precipitation is 25 to 30 inches, the average annual temperature ranges from 42° to 45° F., and the frost-free period is 80 to 100 days. The overstory is mostly ponderosa pine and some Douglas-fir, white fir, limber pine, Gambel oak, and aspen. The understory is a sparse cover of mountain muhly, pine dropseed, squirreltail, junegrass, wild pea, Fendler ceanothus, and scattered areas of ferns. The Palomino soils are in the same general areas as the Sanchez, McVickers, and Soldier soils.

In a representative profile the surface layer is brown very stony fine sandy loam about 2 inches thick. The subsoil is reddish-brown sandy clay loam about 13 inches thick that rests on bedrock. The profile is noncalcareous and neutral throughout.

Permeability is moderately slow. The available water capacity is 2 to 40 inches in the 12 to 20 inches of effective rooting depth.

Palomino soils are used for timber production, summer livestock grazing, and wildlife.

Representative profile of Palomino very stony fine sandy loam, 0 to 15 percent slopes, in an area of ponderosa pine, NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 18, T. 12 N., R. 11 E., Coconino County:

O1 & O2—2 inches to 0, raw and partly decomposed pine needle litter.

A1—0 to 2 inches, brown (10YR 5/3) very stony fine sandy loam, dark brown (10YR 3/3) moist; weak, fine, granular structure; soft, friable, slightly sticky and slightly plastic; common very fine and fine roots; many micro and very fine interstitial pores; 5 per-

cent gravel and 5 percent cobblestones; neutral (pH 6.6); abrupt, smooth boundary.

B21t—2 to 8 inches, reddish-brown (5YR 5/4) light sandy clay loam, reddish brown (5YR 4/4) moist; massive parting to moderate, medium, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common fine and medium roots and few coarse roots; many micro and very fine interstitial pores; common thin clay bridges; 5 percent gravel and 5 percent cobblestones; neutral (pH 6.6); clear, smooth boundary.

B22t—8 to 15 inches, reddish-brown (5YR 5/4) sandy clay loam, reddish brown (5YR 4/4) moist; massive parting to moderate, medium, subangular blocky structure; slightly hard, friable, sticky and plastic; common medium and coarse roots and few fine roots; many micro and very fine interstitial pores; common thin clay bridges; 5 percent gravel and 5 percent cobblestones; neutral (pH 6.6); abrupt, irregular boundary.

R—15 inches, sandstone bedrock, slightly weathered and fractured on surface.

Depth to bedrock is mostly 15 to 18 inches, but ranges from 12 to 20 inches. The A horizon is fine sandy loam, cobbly or very stony fine sandy loam, or loam. It is of 10YR to 5YR hue; value is 4 or 5 dry and 2 or 3 moist, and chroma is 3 or 4. The B horizon is heavy fine sandy loam, light sandy clay loam, or sandy clay loam. It is of 5YR to 7.5YR hue; value is 4 or 5 dry and 3 or 4 moist, and chroma is 3 or 4.

Palomino very stony fine sandy loam, 0 to 15 percent slopes (PaC).—This soil is on uplands in the southern part of the Area near the Mogollon Rim. Slopes are dominantly less than 4 percent. Stone cover on the surface ranges from 5 to 25 percent, but is typically 10 to 15 percent.

Included areas of soils that are 25 to 30 inches deep over bedrock, some of which have a clay subsoil, make up 10 to 15 percent of the total acreage of this soil, and Sanchez soils make up 5 to 10 percent. Also included are small areas of Soldier soils and small areas where this Palomino soil is 50 percent sandstone outcrop. Permanent and intermittent lakes $\frac{1}{2}$ acre to 2 acres in size are within this mapping unit.

Runoff is slow. The erosion hazard is slight.

This Palomino soil is in timber group 2b, range herbage group 4, range improvement group 3, recreation group 3a, and capability subclass VIc dryland.

Penthouse Series

The Penthouse series consists of nearly level to strongly sloping, well-drained soils that formed in sediment weathered from limestone, basalt, and sandstone. These soils are on old, high terraces and on the lower parts of fans in the western part of the Area. Slopes range from 0 to 10 percent. These soils are in grassland-desert shrub vegetation, at an elevation of 3,200 to 4,400 feet. The estimated annual rainfall is 12 to 13 inches, the average annual temperature is 60° to 64° F., and the frost-free period is 200 to 230 days. The vegetation is mainly mesquite, snakeweed, pricklypear, filaree, and tobosa. Normally as much as 20 percent of the acreage is barren. These soils are associated with Bridge, Guest, House Mountain, Retriever, and Rimrock soils.

In a representative profile the surface layer is brown cobbly loam and clay loam about 5 inches thick. The subsoil, about 33 inches thick, is brown clay, reddish-brown gravelly clay, and reddish-yellow very cobbly

clay. The substratum is reddish-brown cobbly clay to a depth of 60 inches or more.

Permeability is very slow. The available water capacity is 7 to 9 inches in the 24 to 40 inches of effective rooting depth.

Penthouse soils are used as winter livestock range and wildlife habitat.

Representative profile of Penthouse cobbly loam, 0 to 10 percent slopes, in an area of range, SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 14, T. 13 N., R. 5 E., Yavapai County:

A11—0 to 2 inches, brown (7.5YR 5/4) cobbly heavy loam, dark reddish brown (5YR 3/3) moist; moderate, fine and medium, platy structure; slightly hard, friable, slightly sticky and slightly plastic; few very fine roots; common very fine and fine tubular pores; 15 percent cobbles; moderately alkaline (pH 8.0); abrupt, smooth boundary.

A12—2 to 5 inches, brown (7.5YR 5/4) light clay loam, dark reddish brown (5YR 3/4) moist; weak, coarse, platy structure parting to weak, medium, subangular blocky structure; hard, friable, sticky and plastic; few very fine and fine roots; many very fine and fine tubular pores and few medium tubular pores; few pebbles and cobbles; moderately alkaline (pH 8.2); clear, smooth boundary.

B21t—5 to 12 inches, brown (7.5YR 5/4) light clay, dark brown (7.5YR 4/4) moist; moderate, medium, subangular and angular blocky structure; very hard, friable, sticky and plastic; few very fine, fine, and medium roots; many very fine and fine tubular pores and few medium tubular pores; few thin clay films on ped faces and in pores; 5 percent cobbles; moderately alkaline (pH 8.2); clear, smooth boundary.

B22t—12 to 23 inches, brown (7.5YR 5/4) clay, dark brown (7.5YR 3/2) moist; moderate, fine and medium, angular blocky structure; very hard, firm, sticky and plastic; few very fine, fine, and coarse roots; many very fine and fine interstitial pores and few medium interstitial pores; common thin clay films on ped faces and in pores; 10 percent cobbles, few stones; common fine white lime filaments; slightly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

B23t—23 to 28 inches, reddish-brown (5YR 5/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate, fine and medium, subangular and angular blocky structure; very hard, firm, sticky and plastic; few very fine and fine roots; many very fine and fine interstitial pores and few medium interstitial pores; common moderately thick clay films on ped faces and in pores; 15 percent gravel; common fine white lime filaments; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

B3tca—28 to 38 inches, reddish-yellow (5YR 6/6) very cobbly clay, yellowish red (5YR 4/6) moist; massive; hard, firm, sticky and plastic; few very fine roots; common very fine and fine tubular pores; 60 percent cobbles and 20 percent gravel; common fine lime filaments and many lime coatings on underside of gravel and cobbles; strongly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C—38 to 60 inches, reddish-brown (5YR 5/4) cobbly clay, yellowish red (5YR 4/6) moist; massive; very hard, firm, sticky and plastic; few very fine roots; common very fine and fine tubular pores; 25 percent gravel and cobbles; slightly effervescent; moderately alkaline (pH 8.2).

The A horizon is cobbly loam, light clay loam, stony loam, or cobbly clay loam. It is of 10YR hue; value is 5 or 6 dry and 3 or 4 moist. The B2t horizon is heavy clay loam, light clay, clay, or gravelly and cobbly clay. Value ranges from 4 to 6 dry, and chroma is 2 to 6. Depth to the gravelly or very gravelly and cobbly horizon is commonly 30 inches, but ranges from 24 to 40 inches.

Penthouse cobbly loam, 0 to 10 percent slopes (PeC).—

This cobbly and gravelly soil is on old terraces and fans. Slopes range from 0 to 10 percent, but are dominantly 2 to 5 percent. Gravel covers 20 to 40 percent of the surface area, cobbles 15 to 40 percent, and stones about 5 percent.

Included areas of Rimrock soils make up about 10 percent of the total acreage of this soil. Also included are small areas of Graham soils and several small areas where 50 to 70 percent of the surface area of this Penthouse soil is covered with cobbles and gravel.

Runoff is medium. The erosion hazard is moderate.

This Penthouse soil is in range herbage group 3, range improvement group 2, recreation group 2a, and capability subclass V1e dryland.

Retriever Series

This series consists of gently sloping to very strongly sloping, well-drained soils that are 6 to 20 inches deep over bedrock. These soils formed in residuum weathered from limestone. They are on uplands and mesa tops in the Verde Valley. Slopes range from 0 to 30 percent. The elevation is 3,100 to 4,100 feet. Annual rainfall is 10 to 13 inches, the average annual temperature is 60° to 64° F., and the frost-free period 200 to 230 days. The vegetation is canotia, creosotebush, pricklypear, cholla, snakeweed, algerita, side-oats grama, black grama, and sand dropseed. About 40 to 60 percent of the acreage is barren. These soils are associated with Bridge, Graham, Guest, Glendale, and Penthouse soils.

In a representative profile the surface layer is light brownish-gray very stony loam about 3 inches thick. The underlying layer is pinkish-gray gravelly loam that rests on limestone at a depth of about 9 inches. The profile is strongly to violently effervescent and moderately alkaline throughout.

Permeability is moderate. The available water capacity is 1½ to 3 inches in the 6 to 20 inches of effective rooting depth.

Retriever soils are used as winter range and wildlife habitat.

Representative profile of Retriever very stony loam, 0 to 30 percent slopes, in an area of range, NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 19, T. 14 N., R. 6 E., Yavapai County:

A1—0 to 3 inches, light brownish-gray (10YR 6/2) very stony loam, dark brown (10YR 4/3) moist; weak, fine, granular structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; many medium and very fine interstitial pores; 25 percent stones, 20 percent gravel; violently effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

C—3 to 9 inches, pinkish-gray (7.5YR 7/2) gravelly loam, brown (7.5YR 5/4) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common fine, medium, and coarse roots; many medium and very fine interstitial pores; 25 percent gravel, 10 percent cobbles; violently effervescent; moderately alkaline (pH 8.4); clear, irregular boundary.

R—9 inches, limestone bedrock, slightly fractured and slightly weathered.

The A horizon is very stony loam, stony loam, gravelly loam, or gravelly sandy loam. It is of 10YR hue; value is 5 to 7 dry. The C horizon is gravelly loam, gravelly sandy loam, or gravelly light clay loam. It is dominantly of 7.5YR hue, but ranges from 10YR to 5YR; value is 5 to 7 dry.

The profile is 15 to 35 percent gravel and stones. Depth to bedrock ranges from 6 to 20 inches, but is most commonly 8 to 12 inches.

Retriever loam, 0 to 10 percent slopes (ReC).—This very shallow to shallow soil is on uplands. It is not stony, but otherwise has a profile similar to the one described as representative of the series. Slopes are dominantly 2 to 5 percent.

Inclusions of Glendale soils make up 5 percent of the total acreage of this soil. Also included are small areas where gravel covers 25 percent of the surface area.

This Retriever soil is in range herbage group 4, range improvement group 3, recreation group 3a, and capability subclass VIIIs dryland.

Retriever very stony loam, 0 to 30 percent slopes (RsD).—This soil is on uplands, mesas, and the sides and low, rounded tops of ridges (fig. 16). Slopes are mostly 15 to 25 percent, but some are as much as 40 percent. Stones typically cover 15 to 20 percent of the surface area, gravel 25 to 35 percent, and limestone outcrop as much as 10 percent. This soil has the profile described as representative of the series.

Inclusions of Glendale soils in depressions and along drainageways make up about 5 percent of the total acreage of this soil. Also included are small areas of soils that are similar to Retriever soils but have a limepan above the limestone.

Runoff is medium to rapid. The erosion hazard is moderate to high. Deep gullies have formed in some of the alluvial inclusions.

This Retriever soil is in range herbage group 4, range improvement group 3, recreation group 3b, and capability subclass VIIIs dryland.

Rimrock Series

The Rimrock series consists of nearly level to strongly sloping, well-drained soils that are 24 to 60 inches deep over bedrock. These soils are on old fans and mudflows. They formed in residuum weathered from basalt, cinders, and volcanic ash. Slopes range from 0 to 10 percent. Elevation is 3,200 to 4,400 feet. Annual rainfall is 12 to 13 inches, the average annual temperature is about 61° F., and the frost-free period is 200 to 230 days. The vegetation is tobosa, mesquite, catclaw, pricklypear, filaree, and annual grasses. Associated soils are Graham, House Mountain, Retriever, Penthouse, and Bridge soils.

In a representative profile the surface layer is reddish-brown cobbly clay about 2 inches thick. The underlying layers are reddish-brown clay, about 32 inches thick, that rests on basalt cobblestones or on volcanic ash, cinders, and tuff. The profile is calcareous and moderately alkaline throughout. Wide, deep cracks form as these soils dry.



Figure 16.—Retriever very stony loam, 0 to 30 percent slopes. The gently sloping area in the foreground is Glendale soil.

Permeability is slow. The available water capacity is 4 to 9 inches in the 24 to 60 inches of effective rooting depth.

Rimrock soils are used as livestock range and wildlife habitat.

Representative profile of Rimrock cobbly clay, 0 to 10 percent slopes, in an area of range, SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 30, T. 13 N., R. 6 E., Yavapai County:

A1—0 to 2 inches, reddish-brown (5YR 4/4) cobbly clay, dark reddish brown (5YR 3/4) moist; moderate, fine and medium, granular structure; slightly hard, friable, sticky and very plastic; common fine roots; common very fine and fine tubular pores; 20 percent cobbles, 15 percent gravel; slightly effervescent; moderately alkaline (pH 8.0); abrupt, smooth boundary.

C1—2 to 11 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; massive; very hard, firm, sticky and very plastic; few fine roots; common very fine and fine tubular pores; few pebbles and cobbles; strongly effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

C2—11 to 34 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) moist; massive; very hard, firm, sticky and very plastic; very few very fine and fine roots; common very fine and fine tubular pores; few pebbles and cobbles; many medium and large slickensides that intersect; strongly effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

R—34 inches, very hard tuff and volcanic ash.

This soil is clay throughout. It is typically of 5YR hue, but ranges from 7.5YR to 2.5YR; value is 3 to 5 dry and 2 to 4 moist, and chroma is 2 to 4. Slickensides are common throughout the soil, and evidence of churning is apparent in the gilgai relief.

Rimrock cobbly clay, 0 to 10 percent slopes (R₁C).—This soil is on old alluvial fans and mesas and in saddle-like depressions. Slopes are dominantly less than 5 percent. Gravel covers 15 to 30 percent of the surface area, and cobbles 15 to 25 percent.

Included with this soil in mapping are some areas of soils that are similar to Rimrock soils but have saddlelike relief and are only 18 to 20 inches deep over basalt bedrock.

Runoff is very slow on dry soils and moderate to high on moist soils. The erosion hazard is moderate, but there are numerous gullies.

This soil is in range herbage group 3, range improvement group 2, recreation group 5a, and capability subclass VIIe dryland.

Sanchez Series

The Sanchez series consists of nearly level to strongly sloping, well-drained soils that are 8 to 20 inches deep over bedrock. These soils formed on uplands on the Coconino Plateau in residuum weathered from sandstone. Slopes range from 0 to 15 percent. Elevation is 7,200 to 7,800 feet. Annual precipitation is 25 to 30 inches, the average annual temperature is 42° to 45° F., and the frost-free period is 80 to 100 days. The overstory is chiefly an open stand of low-quality ponderosa pine, but it includes some Douglas-fir, white fir, limber pine, and Gambel oak. The understory is mainly squirreltail, junegrass, mountain muhly, pine dropseed, and very few shrubs and forbs. Associated soils are McVickers, Palomino, and Soldier soils.

In a representative profile the surface layer is pale-brown extremely stony sandy loam about 13 inches thick. The subsoil is yellowish-red extremely stony sandy clay loam. Sandstone bedrock is at a depth of about 19 inches. A typical profile is more than 50 percent stones, cobbles, and gravel. It is neutral in reaction and non-calcareous throughout.

Permeability is moderate. The available water capacity is 1 to 2 inches in the 8 to 20 inches of effective rooting depth.

Sanchez soils are used for timber, summer livestock grazing, and wildlife.

Representative profile of Sanchez extremely stony sandy loam, 0 to 15 percent slopes, in an area of ponderosa pine, SE $\frac{1}{4}$ sec. 1, T. 12 N., R. 10 E., Coconino County:

O1 & O2—2 inches to 0, raw and decomposing pine needles and oak leaves.

A21—0 to 7 inches, pale-brown (10YR 6/3) extremely stony sandy loam, brown (10YR 4/3) moist; massive; soft, friable, nonsticky and nonplastic; common very fine, fine, and medium roots and few coarse roots; many micro and very fine interstitial pores; 45 percent cobbles; neutral (pH 6.6); clear, irregular boundary.

A22—7 to 13 inches, pale-brown (10YR 6/3) extremely stony heavy sandy loam, brown (7.5YR 4.4) moist; massive; slightly hard, friable, slightly sticky and nonplastic; many medium and coarse roots and few fine roots; many micro and very fine interstitial pores; 60 percent stones and 15 percent cobbles; neutral (pH 6.8); clear, irregular boundary.

B2t—13 to 19 inches, yellowish-red (5YR 5/6) extremely stony sandy clay loam, yellowish red (5YR 4/8) moist; massive; hard, firm, slightly sticky and plastic; few fine, medium, and coarse roots; many micro and very fine interstitial pores; common thin clay films in pores and as bridges; 60 percent stones and 15 percent cobbles; neutral (pH 7.0); clear, irregular boundary.

R—19 inches, fractured sandstone bedrock.

Some profiles have a thin sandy loam or fine sandy loam A1 horizon. The A2 horizon is sandy loam or loam. It is 55 to 75 percent stones and cobbles. It is of 7.5YR or 5YR hue. The depth to fractured bedrock ranges from 8 to 20 inches, but is commonly 14 to 16 inches.

Sanchez extremely stony sandy loam, 0 to 15 percent slopes (S₁C).—This soil is on uplands in the southeastern part of the Area near the edge of the Mogollon Rim. Slopes are dominantly about 5 percent, but a few short breaks at the heads of draws are 20 to 30 percent. Stones cover 50 to 60 percent of the surface area.

Inclusions of Palomino soils, typically the less sloping areas, make up about 10 percent of the total acreage of this soil. Also included are small areas of Soldier soils and sandstone ledges and outcrops, which make up about 5 percent of the mapping unit.

Runoff is moderate. The erosion hazard is moderate.

This Sanchez soil is in timber group 3, range herbage group 4, range improvement group 3, recreation group 3a, and capability subclass VIIe dryland.

Siesta Series

The Siesta series consists of nearly level to moderately steep, well-drained soils that are 36 to 60 inches deep over basalt or cinders. These soils are on uplands in the northeastern part of the Area. Elevation ranges from 6,700

to 8,000 feet. Slopes range from 0 to 20 percent. Annual precipitation is about 20 to 25 inches, the average annual temperature is 42° to 45° F., and the frost-free period is 90 to 110 days. The overstory is a thick stand of ponderosa pine and intermingled Gambel oak. The understory is New Mexico locust, mountain muhly, Arizona fescue, squirreltail, and pine dropseed. Associated upland soils are Broliar, Hogg, McVickers, and Sponseller soils. Friana and Luth soils are associated with Siesta soils in open parks and in drainageways.

In a representative profile the surface layer is dark reddish-gray cobbly loam about 5 inches thick. The subsoil is reddish-brown and red clay about 27 inches thick. Weathered cinders are at a depth of about 32 inches. Basalt is at a depth of about 40 inches. The profile is noncalcareous and is neutral to mildly alkaline throughout.

Permeability is slow. The available water capacity is 7 to 10 inches in the 30 to 40 inches or more of effective rooting depth.

Siesta soils are used for timber, grazing, wildlife, and watershed.

Representative profile of Siesta cobbly loam, 0 to 20 percent slopes, in an area of cutover ponderosa pine, NE $\frac{1}{4}$ SW $\frac{1}{4}$, sec. 32, T. 15 N., R. 9 E., Coconino County:

O1 & O2—1 inch to 0, partially decomposed and decomposed pine needles.

A1—0 to 5 inches, dark reddish-gray (5YR 4/2) cobbly loam, dark reddish brown (5YR 3/2) moist; moderate, medium, platy structure and moderate, medium and coarse, granular structure; soft, friable, slightly sticky and slightly plastic; common very fine and fine roots; many micro and very fine interstitial pores; 20 percent cobblestones and 5 percent gravel; neutral (pH 6.8); clear, smooth boundary.

B1—5 to 10 inches, reddish-brown (2.5YR 4/4) light clay, dark reddish brown (2.5YR 3/4) moist; weak, fine, subangular blocky structure; soft, firm, sticky and plastic; common coarse and few fine roots; common very fine tubular pores and few very fine interstitial pores; common thin clay bridges; neutral (pH 6.8); clear, smooth boundary.

B21t—10 to 25 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; moderate, coarse and medium, subangular blocky structure; hard, firm, very sticky and very plastic; few fine and common coarse roots; common very fine tubular pores and common micro and very fine interstitial pores; few thin clay films on ped faces; neutral (pH 6.6); clear, wavy boundary.

B22t—25 to 32 inches, red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; weak, medium and coarse, subangular blocky structure; very hard, very firm, very sticky and plastic; few fine and coarse roots; common micro and very fine interstitial pores; common moderately thick clay films on ped faces; neutral (pH 6.6); clear, irregular boundary.

C—32 to 40 inches, dark reddish-brown (5YR 3/4) mixture of weathered cinders and some soil material from the B22 horizon; massive; common micro and very fine interstitial pores; mildly alkaline (pH 7.8); abrupt, irregular boundary.

R—40 inches, basalt.

The A horizon is cobbly loam, cobbly silt loam, or cobbly clay loam. It is of 7.5YR or 5YR hue; value is 3 to 5 dry and 2 or 3 moist, and chroma is 2 to 4. The B horizon is light clay, clay, or gravelly clay. It is of 2.5YR or 10R hue; value is 3 or 4 dry, and chroma is 4 to 6. The C horizon contains cinders or vesicular basalt cobblestones. It is generally noneffervescent, but contains some lime filaments.

Siesta loam, 0 to 5 percent slopes (Sc8).—This soil is on colluvial toe slopes in the uplands. Nearly level areas are common, and the gently sloping areas have smooth, convex relief. Most areas have a layer of litter 2 to 3 inches thick.

Included areas of the cobbly Siesta soil and small areas of Broliar soils make up about 5 percent of the total acreage of this soil.

Runoff is slow. The erosion hazard is slight.

This Siesta soil is in timber group 1, range herbage group 2, range improvement group 1, recreation group 2a, and capability subclass VIs dryland.

Siesta cobbly loam, 0 to 20 percent slopes (SeD).—This soil is on uplands in the northern part of the Area. It has the profile described as representative of the series. Slopes are dominantly about 5 percent, but range up to 20 percent. Cobblestones, gravel, and welded cinder fragments cover about 20 to 40 percent of the surface area. The steeper areas are more cobbly.

Areas of Siesta loam make up about 5 percent of this mapping unit and Broliar soils make up 10 percent. Also included are a few small areas of Sponseller soils and, in the more cobbly parts, small areas of red soils that are less than 20 inches deep over basalt or cinders.

Runoff is medium. The erosion hazard is moderate.

This Siesta soil is in timber group 2a, range herbage group 2, range improvement group 2, recreation group 2a, and capability subclass VIe dryland.

Soldier Series

The Soldier series consists of nearly level to very steep, well drained and moderately well drained soils that are more than 60 inches deep over bedrock. These soils formed in residuum weathered from cherty limestone and sandstone of the Kaibab Formation. They are above the Mogollon Rim on the Coconino Plateau and are dissected by numerous draws, canyons, and gorges. Slopes range from 0 to 60 percent. Elevation ranges from 7,000 to 8,000 feet. Annual precipitation is 24 to 28 inches, the average annual temperature is 42° F., and the frost-free period is 90 to 110 days. The overstory is ponderosa pine, Gambel oak, and Douglas-fir (fig. 17). White fir and limber pine grow in the more sloping areas and aspen in moist areas at the higher elevations. The understory is New Mexico locust, Arizona fescue, mountain muhly, and junegrass. These soils are associated with McVickers, Palomino, Sanchez, Wildcat, and Clover Springs soils. Clover Springs soils are in drainageways. The rest are on uplands.

In a representative profile the surface layer is brown cobbly loam about 2 inches thick. The subsurface layer is about 17 inches thick. The subsoil is reddish-brown cobbly clay that extends to a depth of more than 60 inches and is mottled below a depth of about 38 inches. The profile is noncalcareous throughout and is neutral to strongly acid.

Permeability is very slow. The available water capacity is 8 to 12 inches in the 60 inches or more of effective rooting depth.

Soldier soils are used for timber, water yield, and wildlife. They also supply some forage for summer grazing of livestock.



Figure 17.—Good stand of ponderosa pine on Soldier cobbly loam, 0 to 10 percent slopes.

Representative profile of Soldier cobbly loam, 0 to 10 percent slopes, in an area of ponderosa pine, SW $\frac{1}{4}$ sec. 17, T. 12 N., R. 11 E., Coconino County:

O1—2 to 1 inch, raw pine needle litter; medium acid (pH 6.0).
O2—1 inch to 0, decomposed pine needle litter; slightly acid (pH 6.2).

A1—0 to 2 inches, brown (10YR 5/3) cobbly loam, dark brown (10YR 3/3) moist; weak, fine, platy structure breaking to moderate, medium, granular structure; soft, friable, slightly sticky and slightly plastic; common very fine and fine roots; many micro and very fine interstitial pores and common very fine tubular pores; neutral (pH 6.6); abrupt, smooth boundary.

A21—2 to 11 inches, light brownish-gray (10YR 6/2) cobbly loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; common fine roots and many medium and coarse roots; many micro and very fine interstitial pores and common very fine tubular pores; 40 percent cobbles and gravel; slightly acid (pH 6.4); clear, wavy boundary.

A22—11 to 19 inches, very pale brown (10YR 7/3) very cobbly sandy loam, brown (10YR 5/3) moist; massive; slightly hard, friable, nonsticky and nonplastic; common very fine, fine, and medium roots; many micro and very fine interstitial pores and common very fine tubular pores; 70 percent subangular chert gravel cobbles; medium acid (pH 6.0); abrupt, irregular boundary.

B21t—19 to 33 inches, reddish-brown (5YR 5/4) cobbly clay, reddish brown (5YR 4/4) moist; common, medium, distinct and faint, light-brown (7.5YR 6/4) and brown (7.5YR 5/4) mottles; strong, medium, sub-

angular and angular blocky structure; very hard, very firm, sticky and very plastic; few coarse roots and common medium roots; common micro and very fine interstitial pores; many moderately thick clay films on ped faces; continuous tongues of A2 material between peds; 30 percent subangular cobbles and gravel; medium acid (pH 5.8); clear, irregular boundary.

B22t—33 to 38 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; many, large, prominent, dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) mottles; strong, medium, subangular and angular blocky structure; very hard, very firm, sticky and very plastic; few fine, medium, and coarse roots; common micro and very fine interstitial pores; many moderately thick clay films on ped faces; 10 percent subangular chert gravel; very strongly acid (pH 5.0); abrupt, wavy boundary.

B3—38 to 62 inches, reddish-yellow (7.5YR 6/8) cobbly clay, dark reddish brown (5YR 3/4) moist; dark yellowish-brown (10YR 4/4), reddish-yellow (7.5YR 7/8), and reddish-brown (5YR 5/4) mottles; massive; very hard, very firm, sticky and plastic; common coarse roots; few micro and very fine interstitial pores; 20 percent cobbles; tongues of B2 horizon; medium acid (pH 5.8).

The A1 horizon is dominantly loam, but is sandy loam or fine sandy loam in places. It is commonly cobbly and gravelly. It is of 10YR or 7.5YR hue; value is 4 or 5 dry and 2 or 3 moist, and chroma is 1 to 3. The A2 horizon is sandy loam or loam. It is of 10YR to 7.5YR hue; value is 6 or 7 dry and 4 or 5 moist, and chroma is 2 to 4. The A2 horizon commonly tongues into the B2 horizon. Some profiles have an A or B

transitional horizon between the A2 and B2 horizons. Typically the B2 horizon is reddish brown and has strong subangular or angular blocky structure. Both the B2 and B3 horizons are mottled.

Soldier cobbly loam, 0 to 10 percent slopes (S1C).—This soil is on the Coconino Plateau, on ridges between draws and canyons. In places the ridgetops are only 300 feet wide. In others they are one-eighth to one-fourth mile wide. Chert cobblestones and gravel cover 25 to 40 percent of the surface area. This soil has the profile described as representative of the series.

About 5 percent of the total acreage of this soil is included areas where the chert from limestone is gravel size and the texture is gravelly loam and gravelly fine sandy loam; about 10 percent is an inclusion of McVickers soils; about 5 percent is Hogg soils; and about 5 percent is an inclusion of Limestone rock land.

Runoff is slow. The erosion hazard is slight.

This Soldier soil is in timber group 1, range herbage group 2, range improvement group 1, recreation group 1a, and capability subclass VIe dryland.

Soldier cobbly loam, 20 to 45 percent slopes (S1E).—This soil is along drainageways, draws, and canyons that dissect the Coconino Plateau. It is closely associated with Soldier cobbly loam, 0 to 10 percent slopes. At the higher elevations it separates the ridgetops occupied by that soil, and at the lower elevations, where the draws and canyons are deeply incised, it is between areas of that soil and steep limestone and sandstone outcrop. The slope gradient is dominantly 30 percent, but is as much as 45 percent in a few places.

Included areas of Clover Springs soils, in the bottoms of small drains that cut into slopes along the draws and canyons, make up 5 percent of the total acreage; included areas of McVickers soils make up about 10 percent; and areas of limestone and sandstone ledges about 10 percent.

Runoff is medium, and the erosion hazard is high.

This Soldier soil is in timber group 1, range herbage group 2, range improvement group 3, recreation group 1b, and capability subclass VIc dryland.

Soldier-McVickers very rocky complex, 20 to 60 percent slopes (S1mF).—This complex is about 45 percent Soldier soils, 30 percent McVickers soils, 20 percent limestone and sandstone outcrop, and 5 percent Hogg soils. It is an area of dense stands of ponderosa pine, very steep slopes, and ledge rock along draws and canyons on the Coconino Plateau.

These soils are in timber group 2a, range herbage group 2, range improvement group 3, recreation group 1b, and capability subclass VIIc dryland.

Sponseller Series

The Sponseller series consists of well-drained soils that are 30 to 72 inches deep over cinders. These soils formed in residuum weathered from basalt and cinders on the sides of cinder cones. Slopes range from 0 to 40 percent. The elevation ranges from 7,000 to 8,400 feet. Annual rainfall is 20 to 24 inches, the average annual temperature is about 45° F., and the frost-free period is 85 to 105 days. The overstory is a dense stand of ponderosa pine and some Gambel oak, Douglas-fir, and aspen. The understory is mountain muhly, Arizona fescue,

Kentucky bluegrass, and New Mexico locust. These soils are associated with Broliar and Siesta soils.

In a representative profile the surface layer is dark reddish-brown gravelly silt loam or loam about 11 inches thick. The subsoil is reddish-brown and yellowish-red heavy loam or light clay loam about 35 inches thick. The substratum is a mixture of yellowish-red very gravelly clay loam and cinders that extends to a depth of 52 inches or more. The profile is noncalcareous and is medium acid to neutral throughout.

Permeability is moderately slow. The available water capacity is 5 to 12 inches in the 30 to 60 inches or more of effective rooting depth.

Sponseller soils are used for timber, summer range, and water yield.

Representative profile of Sponseller gravelly silt loam, in an area of ponderosa pine, NE¼ sec. 29, T. 16 N., R. 9 E., Coconino County:

- O1—1 inch to 0, raw and partly decomposed pine needle litter.
- A1—0 to 3 inches, dark reddish-brown (5YR 3/3) gravelly silt loam, dark reddish brown (5YR 3/2) moist; moderate, fine, granular structure; soft, friable, slightly sticky and slightly plastic; many fine tree roots; many fine interstitial pores; noneffervescent; medium acid (pH 5.9); clear, smooth boundary.
- A3 -3 to 11 inches, dark reddish-brown (2.5YR 3/2) gravelly loam, dark reddish brown (2.5YR 2/2) moist; weak, fine, granular structure; hard, friable, slightly sticky and slightly plastic; many tree roots; common medium interstitial pores; noneffervescent; slightly acid (pH 6.4); clear, smooth boundary.
- B1t—11 to 17 inches, reddish-brown (2.5YR 4/4) gravelly heavy loam, dark red (2.5YR 3/6) moist; moderate, coarse, granular structure; hard, friable, sticky and plastic; few tree roots; many fine interstitial pores; thin discontinuous clay films in pores and on ped faces; noneffervescent; slightly acid (pH 6.4); gradual, wavy boundary.
- B2t—17 to 28 inches, reddish-brown (2.5YR 4/4) gravelly light clay loam, dark red (2.5YR 3/6) moist; moderate, fine, subangular blocky structure; hard, friable, sticky and plastic; few tree roots; common fine interstitial pores; moderately thick clay films on ped faces; noneffervescent; slightly acid (pH 6.4); gradual, smooth boundary.
- B3t—28 to 43 inches, yellowish-red (5YR 4/6) gravelly light clay loam, yellowish red (5YR 4/6) moist; moderate, fine, subangular blocky structure; very hard, firm, sticky and plastic; few tree roots; many fine interstitial pores; thin patchy clay films on ped faces; noneffervescent; slightly acid (pH 6.4); gradual, smooth boundary.
- C1—43 to 52 inches, yellowish-red (5YR 4/6) very gravelly clay loam, yellowish red (5YR 4/6) moist; massive; hard, friable, slightly sticky and slightly plastic; 40 percent cinder gravel; noneffervescent; neutral (pH 7.0); abrupt, irregular boundary.
- C2—52 inches, cinders.

The A horizon is gravelly loam or gravelly silt loam. Value is 3 to 5 dry and 2 to 3 moist. Gravel and cobblestones occur on the surface and throughout the profile. The depth to cinders ranges from 30 to 72 inches. In some profiles the B2t horizon is directly under the A horizon.

Sponseller gravelly silt loam, 10 to 40 percent slopes (S1E).—This soil is on the sides of cinder cones in the northern part of the Area on the Coconino Plateau. Slopes are dominantly 20 to 30 percent. A 1- to 3-inch layer of pine needle litter covers this soil, and cinder gravel covers 5 to 30 percent of the surface area.

Included in mapping and making up 5 percent of the total acreage of this soil are areas where 15 to 20 percent of the surface is covered with cobblestones, stones, and rock outcrop. Also included are small areas of *Siesta* soils on the lower, less steep sides of the cinder cones; and areas of soils that are similar to *Sponseller* soils, but have chromas of 4 to 6 near the surface.

The erosion hazard is moderate.

This *Sponseller* soil is in timber group 1, range herbage group 2, range improvement group 3, recreation group 1b, and capability subclass VIe dryland.

Springerville Series

The *Springerville* series consists of clayey soils that are 36 to more than 60 inches deep over bedrock. These soils formed on uplands above the Mogollon Rim in residuum weathered from basalt and cinders. They are extensive and widespread in the survey area. The elevation ranges from 5,600 to 6,900 feet. Slopes range from 0 to 20 percent. Annual rainfall is about 14 to 18 inches, the average annual temperature ranges from 48° to 56° F., and the frost-free period is 150 to 200 days. These soils are in pinyon-juniper woodland and open grassland. The vegetation is chiefly pinyon pine, Utah juniper, western wheatgrass, squirreltail, blue grama, and side-oats grama. Pricklypear and yucca are common at lower elevations. These soils are associated with *Gem*, *Cabezon*, *Waldroup*, and *Brolliar* soils.

In a representative profile the surface layer is brown cobbly clay about 3 inches thick. The underlying layers are dark-brown and reddish-brown clay and gravelly clay. Bedrock is at a depth of 61 inches.

Permeability is slow to very slow. The available water capacity is 4½ to 9 inches in the 30 to 60 inches of effective rooting depth. Wide, deep cracks form as these soils dry.

Springerville soils are used for livestock and wildlife range. A few small areas are irrigated.

Representative profile of *Springerville* cobbly clay, 0 to 10 percent slopes, in an area of grassland, SW¼ sec. 20, T. 16 N., R. 11 E., Coconino County:

A1—0 to 3 inches, brown (7.5YR 4/2) cobbly clay, dark brown (7.5YR 3/2) moist; moderate, medium, platy structure parting to moderate and strong, fine, granular structure; hard, friable, sticky and plastic; common fine and very fine roots; many micro and very fine interstitial pores; mildly alkaline (pH 7.4); clear, smooth boundary.

C1—3 to 45 inches, dark-brown (7.5YR 3/2) clay, dark brown (7.5YR 3/2) moist; massive; very hard, very firm, very sticky and very plastic; very few very fine roots; common micro and very fine interstitial pores; common to many small, medium, and large slickensides; mildly alkaline (pH 7.6); gradual, wavy boundary.

C2—45 to 61 inches, reddish-brown (5YR 4/4) fine gravelly clay, dark reddish brown (5YR 3/4) moist; massive; very hard, very firm, sticky and very plastic; very few very fine roots; common micro and very fine interstitial pores; 30 percent gravel and 10 percent stones; slightly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

R—61 inches, basalt rock, slightly effervescent on top.

A thin, granular A1 horizon is characteristic of this soil. In places it is cobbly, stony, and gravelly, and in places the entire profile is cobbly and stony. This soil is commonly 60

percent or more clay throughout the profile. It is of 10YR to 5YR hue; value ranges from 3 to 5 dry and 2 to 4 moist, and chroma is 2 to 4. This soil is typically calcareous to the surface, and medium to large lime nodules are common on the surface. During dry periods, cracks 2 to 4 inches wide and several feet deep are evident. Slickensides are common in the C horizon.

Springerville clay, 0 to 10 percent slopes (SpC).—This soil has a profile that is similar to the profile described as representative of the series, but it has very few coarse fragments on the surface. Slope gradients are mainly less than 5 percent. Elevations range from 6,000 to 6,900 feet. The acreage is mostly open grassland.

Many areas of this soil resemble old lake beds and appear to have been under water for a long period (fig. 18). In these areas the soils are commonly non-calcareous to a depth of 3 feet. Many of the other areas of this soil are calcareous to the surface.

Inclusions of *Springerville* cobbly clay make up about 5 percent of the total acreage of this soil.

The erosion hazard is slight.

This *Springerville* soil is in range herbage group 2, range improvement group 2, recreation group 5a, and capability subclasses IIIe irrigated and VIe dryland.

Springerville cobbly clay, 0 to 10 percent slopes (SrC).—This soil has the profile described as representative of the *Springerville* series. It is in large tracts on uplands in the northern and west-central parts of the survey area. The elevations range from 5,600 to 6,900 feet. At the higher elevations, in the northern part of the Area, juniper is less dense and grass is more abundant. At the lower elevations juniper is very dense and grass is sparse. Slope gradients are commonly 5 percent, but range up to 15 percent. Cobblestones typically cover 15 to 30 percent of the surface area. Gravel covers 10 to 20 percent of some areas.

Included with this soil in mapping are areas of *Gem* soils, which make up 15 percent of the total acreage; areas of *Cabezon* soils, which make up less than 5 percent; and some areas of basalt rock land. These shallow soils and rocky areas are typically on the breaks of slopes along drainageways and watercourses. Also included are small areas of *Springerville* soils that are nearly free of coarse fragments on the surface.

Runoff is slow when the soil is dry, but is medium to rapid when the soil is moist. The erosion hazard is moderate.

This *Springerville* soil is in range herbage group 2, range improvement group 2, recreation group 5a, and capability subclass VIe dryland.

Springerville-Gem complex, 0 to 20 percent slopes (SsD).—This complex is 60 percent *Springerville* cobbly clay and about 30 percent *Gem* cobbly clay loam. The remaining 10 percent is mostly *Cabezon* soils and a few areas of basalt rock land. Slopes are commonly less than 5 percent, but are as much as 30 percent in a few places. The basalt flows and mesas in the uplands are nearly level to moderately steep.

The soils of this complex are intermingled and the boundaries are abrupt. The landscape has no definable pattern. The largest mapped area is in the northernmost part of the survey area. The profile of the *Gem* soil is described under the heading "*Gem* Series."



Figure 18.—Springerville clay near Long Lake.

Runoff is medium to rapid. The erosion hazard is moderate.

These soils are used as summer livestock range and wildlife habitat. They are in range herbage group 2, range improvement group 2, recreation group 5a, and capability subclass VIe dryland.

Stony Rough Land, Ash and Tuff

Stony rough land, ash and tuff (St) consists of hilly to very steep exposures of ash, tuff, and rhyolite; many vertical cliffs and escarpments; and small tracts of very shallow and shallow soils.

The soils resemble Bridge and House Mountain soils. They are loamy and very gravelly, stony, and cobbly. There is no uniformity in soil pattern.

Slopes are dominantly 40 to 65 percent, but range from 10 to 75 percent. The 10 to 40 percent gradients are in the Cottonwood Basin and West Clear Creek areas. Elevations are 3,400 to 5,600 feet. Annual rainfall is 12 to 16 inches.

From 50 to 70 percent of the acreage is barren. The rest supports only sparse grassland-desert shrub and pinyon pine-juniper vegetation. Among the woody plants are mesquite, pricklypear, cholla, canotia, century plant, desert ceanothus, shrub live oak, mountain-mahogany, manzanita, and juniper and pinyon pine trees. The

grasses are sand dropseed, Arizona cottontop, curly mesquite, fluffgrass, side-oats grama, hairy grama, and black grama.

Stony rough land, ash and tuff, is poorly suited to range herbage production. Grazing is limited to the less sloping parts. The vegetation recovery capacity is low. Under heavy rainfall, the rapid runoff provides surface water yield. The erosion hazard is high. The wide range of topographic features at the higher elevations and the desert-type geologic erosion surfaces are spectacular.

This land type is in range herbage group 5, range improvement group 3, recreation suitability group 5b, and capability subclass VIIs dryland.

Tortugas Series

The Tortugas series consists of nearly level to moderately steep, well-drained soils that are 4 to 18 inches deep over bedrock. These soils are on uplands. They formed in residuum weathered from sandstone, shale, and limestone. The elevation ranges from 6,200 to 6,800 feet. Slopes range from 0 to 30 percent. Annual rainfall is 12 to 17 inches, the average annual temperature 50° to 56° F., and the frost-free period 160 to 190 days. These soils are chiefly in the pinyon-juniper woodland; some are in ponderosa pine. Pinyon pine and Utah juniper are the chief species at lower elevations. An open stand of

poor-quality ponderosa pine, some Gambel oak, and alligator juniper are at higher elevations. The understory is cliffrose, algerita, side-oats grama, blue grama, wolf-tail, and buckwheat. These soils are associated with Dye, Jacks, Winona, and Lynx soils.

In a representative profile the surface layer is dark grayish-brown very stony loam about 8 inches thick. The underlying layer is grayish-brown cobbly heavy loam about 5 inches thick. Limestone bedrock is at a depth of 13 inches.

Permeability is moderate. The available water capacity is $1\frac{1}{2}$ to 3 inches in the 4 to 18 inches of effective rooting depth.

Tortugas soils provide wildlife habitat and seasonal livestock grazing.

Representative profile of Tortugas very stony loam, 0 to 30 percent slopes, in an area of native range, SE $\frac{1}{4}$ sec. 8, T. 15 N., R. 12 E., Coconino County:

A11—0 to 2 inches, dark grayish-brown (10YR 4/2) very stony loam, very dark brown (10YR 2/2) moist; moderate, fine, granular structure; soft, very friable, sticky and slightly plastic; common very fine and fine roots; many very fine and fine interstitial pores; 40 percent gravel and 20 percent stones; slightly effervescent; moderately alkaline (pH 8.2); abrupt, smooth boundary.

A12—2 to 8 inches, dark grayish-brown (10YR 4/2) very stony loam, very dark brown (10YR 2/2) moist; weak, fine and medium, subangular blocky structure; slightly hard, very friable, slightly sticky and plastic; many very fine and fine roots and few medium roots; many fine and very fine interstitial pores and few fine tubular pores; 40 percent gravel and 20 percent stones; solution pitting on surface and lime drips on the lower side of cobbles and pebbles; strongly effervescent; moderately alkaline (pH 8.2); clear, wavy boundary.

C—8 to 13 inches, grayish-brown (10YR 5/2) cobbly heavy loam, dark brown (10YR 3/3) moist; massive; hard, friable, sticky and plastic; common very fine and fine roots; many very fine and fine interstitial pores and few fine tubular pores; 30 percent gravel and 30 percent cobbles; strongly effervescent; moderately alkaline (pH 8.4); abrupt, wavy boundary.

R—13 inches, limestone bedrock, extremely hard, strongly effervescent.

Depth to bedrock is commonly 10 to 14 inches but ranges from 4 to 18 inches. The A horizon is very stony loam or very stony fine sandy loam. It is of 10YR and 7.5YR hue; value is 4 or 5 dry and 2 or 3 moist, and chroma is 2 and 3. The C horizon is very gravelly loam or cobbly heavy loam. It is of 10YR to 5YR hue; value is 4 to 5 dry and 2 to 3 moist, and chroma is 2 to 4. This soil is gravelly, cobbly, or stony on the surface and throughout the profile.

Tortugas very stony loam, 0 to 30 percent slopes (ToD).—This soil formed over Kaibab Limestone on uplands in the north-central part of the Area. Slopes are dominantly 20 to 30 percent; some are about 5 percent, and a few are 30 to 50 percent. Stones, cobbles, and gravel cover 15 to 25 percent of the surface area. Rock outcrop typically covers about 5 percent of the surface area. In the steeper areas it covers as much as 15 percent.

Included with this soil in mapping are Winona soils, which make up about 5 to 10 percent of the total acreage; small areas of Dye and Jacks soils; and areas of Lynx soils in narrow drainageways. Also included are areas of a soil, in the Red Hill region, that is similar to Tortugas soils, but is reddish and has a clay loam underlying layer.

Runoff is medium to rapid. The erosion hazard is moderate.

This Tortugas soil is in range herbage group 4, range improvement group 3, recreation group 3a, and capability subclass VIIIs dryland.

Waldroup Series

The Waldroup series consists of moderately sloping to moderately steep, well-drained soils that are 35 to 50 inches deep over cinders. These soils formed in ash, cinders, and residuum weathered from basalt. They are on the toe slopes, sides, and remnants of cinder cones, and on cinder uplands. Elevations range from 5,600 to 6,500 feet. Slopes range from 5 to 30 percent. Annual rainfall is 15 to 17 inches, the average annual temperature is about 55° F., and the frost-free period ranges from 170 to 200 days. Vegetation is Utah juniper, alligator juniper, shrub live oak, cliffrose, ceanothus, snakeweed, prickly-pear, blue grama, spike muhly, and forbs. These soils are associated with Cabezon, Gem, and Springerville soils.

In a representative profile the surface layer is reddish-brown gravelly silty clay loam about 7 inches thick. The subsoil is dark reddish-brown and weak-red clay and gravelly clay about 28 inches thick. The substratum is reddish-brown and gray very gravelly and cindery clay loam about 3 inches thick. Raw and partially weathered cinders are at a depth of 38 inches. Typically the upper part of the profile is noneffervescent, but effervescence increases with increasing depth. Reaction is mildly to moderately alkaline.

Permeability is slow. The available water capacity is 6 to 8 inches in the 35 to 50 inches of effective rooting depth.

Waldroup soils are used as livestock and wildlife range.

Representative profile of Waldroup gravelly silty clay loam, 5 to 30 percent slopes, in an area of range, SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 21, T. 13 N., R. 7 E., Yavapai County:

A11—0 to 2 inches, reddish-brown (5YR 4/3) gravelly light silty clay loam, dark reddish brown (2.5YR 2/4) moist; moderate, fine, granular structure; slightly hard, friable, sticky and plastic; many very fine and fine roots; many micro and very fine interstitial pores; 45 percent gravel; mildly alkaline (pH 7.4); abrupt, smooth boundary.

A12—2 to 7 inches, reddish-brown (5YR 4/3) light silty clay loam, dark reddish brown (2.5YR 3/4) moist; moderate, fine and medium, subangular and angular blocky structure; hard, friable, sticky and plastic; common very fine and fine roots; common very fine and fine tubular pores; 5 percent gravel, 10 percent stones and cobbles; mildly alkaline (pH 7.6); clear, smooth boundary.

B21t—7 to 20 inches, dark reddish-brown (2.5YR 3/4) clay, dark reddish brown (2.5YR 2/4) moist; moderate, medium and coarse, subangular and angular blocky structure; very hard, very firm, sticky and very plastic; few very fine roots; few very fine and fine tubular pores; many thin clay films on ped faces and in pores; less than 5 percent gravel, cobbles, and stones; mildly alkaline (pH 7.6); gradual, smooth boundary.

B22t—20 to 29 inches, weak-red (2.5YR 4/2) clay, dark reddish brown (2.5YR 3/4) moist; weak, medium and coarse, subangular and angular blocky structure; very hard, very firm, sticky and very plastic; few very fine roots; few very fine and fine tubular pores; common thin clay films on ped faces; few

pebbles, cobblestones, and stones; common medium slickensides and pressure faces; moderately alkaline (pH 8.0); clear, wavy boundary.

B23t—29 to 35 inches, weak-red (2.5YR 4/2) gravelly clay, dark reddish brown (2.5YR 3/4) moist; massive parting to weak, fine and medium, subangular and angular blocky structure; very hard, very firm, sticky and very plastic; very few very fine roots; few very fine and fine tubular pores; common thin clay films on ped faces; 20 percent gravel, 5 percent cobblestones, 5 percent stones; common medium slickensides and pressure faces; very slightly effervescent; moderately alkaline (pH 8.0); clear, smooth boundary.

C—35 to 38 inches, reddish-brown (2.5YR 5/4) and gray (2.5YR N5/0) very gravelly clay loam, red (2.5YR 4/6) and weak red (2.5YR 4/2) moist; massive; very hard, friable, slightly sticky and slightly plastic; very few very fine roots; common very fine and fine tubular pores; many medium slickensides; 75 percent gravel; slightly to strongly effervescent; moderately alkaline (pH 8.2); gradual, wavy boundary.

C2—38 inches, mottled red (2.5YR 5/8), gray (2.5Y N6/0), and yellowish-red (5YR 4/6) weathered and raw cinders.

The deeper soils are on the colluvial toe slopes. The A horizon is gravelly silty clay loam, gravelly silt loam, or gravelly loam. The B horizon is clay, heavy clay loam, gravelly clay, or gravelly clay loam.

Waldroup gravelly silty clay loam, 5 to 30 percent slopes (WcD).—This soil is on toe slopes and sides of cinder cones and on cinder uplands in the west-central part of the Area. Gravel covers 20 to 60 percent of the surface area, and cobblestones 5 to 15 percent. Rock crops out in a few places.

Included areas of Springerville soils on toe slopes make up about 10 percent of the total acreage of this soil; Gem soils make up about 5 percent, and Cabezon soils less than 5 percent.

Runoff is medium to rapid. The erosion hazard is moderate to high. Erosion is slight to moderate in most areas, but in many of the less sloping areas at the base of cinder cones and on toe slopes, gullies 1 to 2 feet deep have formed.

This Waldroup soil is in range herbage group 3, range improvement group 2, recreation group 2b, and capability subclass VIe dryland.

Wildcat Series

The Wildcat series consists of nearly level to hilly, somewhat poorly drained soils that are 20 to 50 inches deep over bedrock. These soils formed in residuum weathered from sandstone on uplands of the Coconino Plateau. Slopes range from 0 to 20 percent. Elevations range from 6,800 to 7,400 feet. Annual rainfall is 18 to 22 inches, the average annual temperature is 44° to 47° F., and the frost-free period is 100 to 120 days. The overstory is open stands of ponderosa pine, alligator juniper, and some Gambel oak. The understory is Arizona fescue, western wheatgrass, squirreltail, junegrass, spike muhly, and a few forbs. Associated soils are Broliar, Soldier, and McVickers soils. Clover Springs soils occupy drainageways.

In a representative profile the surface layer is light brownish-gray and light-gray gravelly fine sandy loam or loam about 7 inches thick. The subsoil is brown, red, light

brownish-gray, and yellowish-red mottled clay that is 25 inches thick. Sandstone is at a depth of about 32 inches. The profile is neutral to strongly acid throughout.

Permeability is very slow. The available water capacity is 4 to 8 inches in the 20 to 50 inches of effective rooting depth.

Wildcat soils are used for timber, summer grazing, and wildlife.

Representative profile of Wildcat gravelly fine sandy loam, 0 to 5 percent slopes, in an area of cutover ponderosa pine, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 28, T. 14 N., R. 12 E., Coconino County:

O2— $\frac{1}{2}$ inch to 0, thin layer of partially decayed pine needles and leaves.

A21—0 to 2 inches, light brownish-gray (10YR 6/2) gravelly fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak, medium and coarse, platy structure parting to moderate, fine, granular structure; slightly hard, very friable, nonsticky and slightly plastic; common fine roots; many fine interstitial pores; 10 percent cobblestones, and stones; neutral (pH 6.6); abrupt, smooth boundary.

A22—2 to 7 inches, light-gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; massive; slightly hard, friable, nonsticky and slightly plastic; common fine and medium roots; many fine interstitial pores and few fine tubular pores; neutral (pH 6.7); abrupt, wavy boundary.

B21t—7 to 17 inches, brown (7.5YR 5/4), red (2.5YR 4/6), and light brownish-gray (2.5Y 6/2) clay, dark brown (7.5YR 4/4), dark red (2.5YR 3/6), and grayish brown (2.5Y 5/2) moist; many, fine and medium, distinct mottles; weak, medium, prismatic structure parting to strong, medium and coarse, angular blocky structure; extremely hard, very firm, sticky and very plastic; common fine, medium, and coarse roots; few fine tubular pores; common pressure faces; continuous moderately thick clay films on ped faces; few pebbles and cobblestones; medium acid (pH 5.6); gradual, wavy boundary.

B22t—17 to 32 inches, light brownish-gray (2.5Y 6/2), yellowish-red (5YR 5/6), and reddish-yellow (7.5YR 6/6) clay, grayish brown (2.5YR 5/2), yellowish-red (5YR 4/6), and dark brown (7.5YR 4/4) moist; many, fine and medium, distinct mottles; weak, coarse, angular blocky structure; extremely hard, extremely firm, sticky and very plastic; few fine, medium, and coarse roots; few fine tubular pores; common pressure faces; few pebbles and cobblestones; strongly acid (pH 5.4); abrupt, irregular boundary.

R—32 inches, very pale brown (10YR 7/3) and red (2.5YR 4/6), extremely hard, dense, fine-grained sandstone; clay tongues extend into fractures.

The A2 horizon is loam, gravelly fine sandy loam, or gravelly sandy loam. It is of 10YR and 7.5YR hue; value is 3 to 5 moist, and chroma is 2 or 3. The B2 horizon is mottled heavy clay. It is dominantly of 5YR hue, but ranges from 2.5YR to 2.5Y; value is 4 to 6 dry and 3 to 5 moist, and chroma is 2 to 6. The B2 horizon ranges from strongly acid to neutral; typically the pH decreases with increasing depth.

Wildcat gravelly fine sandy loam, 0 to 5 percent slopes (WcB).—This soil is on sandstone uplands of the Coconino Plateau. It has the profile described as representative of the series. Slope gradient is dominantly about 3 percent. Gravel covers 30 to 50 percent of the surface area.

Inclusions of Wildcat very rocky loam make up about 5 percent of the total acreage of this soil. Also included are small areas of Broliar and Soldier soils.

Runoff is slow. The erosion hazard is moderate.

This Wildcat soil is in timber group 2b, range herbage group 3, range improvement group 2, recreation group 2a, and capability subclass VIIw dryland.

Wildcat very rocky loam, 0 to 20 percent slopes (WcD).—This soil is on uplands broken by drainageways and draws. Slopes are dominantly 10 percent or less, but are as much as 30 to 40 percent along drainageways and draws. About 20 percent of the surface area is rock outcrop, and 20 to 40 percent is covered with stones. Otherwise, this soil has a profile similar to the one described as representative of the series. Stones are more numerous in the steeper areas.

Included with this soil in mapping are areas of Brol-liar and Soldier soils, which make up nearly 5 percent of the total acreage, and small areas of McVickers soils. In the steeper parts are included areas of soils that make up about 10 percent of the total acreage and are similar to Wildcat soils, but are about 20 inches deep over bedrock and have a discontinuous B horizon.

Runoff is moderate. The erosion hazard is moderate.

This Wildcat soil is in timber group 3, range herbage group 4, range improvement group 3, recreation group 2b, and capability subclass VIIs dryland.

Winona Series

The Winona series consists of nearly level to strongly sloping, well-drained soils that are 6 to 20 inches deep over bedrock. These soils formed on uplands in residuum weathered from Kaibab Limestone and Sandstone. Slopes range from 0 to 10 percent. Elevation ranges from 6,200 to 6,700 feet. Annual rainfall is 12 to 16 inches, the average annual temperature 50° to 58° F., and the frost-free period 150 to 180 days. Vegetation is mainly Utah juniper, alligator juniper, pinyon pine, blue grama, squirreltail, wolftail, cliffrose, fourwing saltbush, skunk-bush, fringed sage, and winterfat. Poor-quality ponderosa pine grows at higher elevations, and the density of the juniper decreases at lower elevations. Associated soils are Dye, Jacks, Lynx, and Tortugas soils.

In a representative profile the surface layer is brown gravelly loam or loam about 9 inches thick. Below this is light-brown gravelly loam about 8 inches thick. Limestone is at a depth of about 17 inches. The profile is typically calcareous and is moderately alkaline throughout.

Permeability is moderate. The available water capacity is 2 to 4 inches in the 6 to 20 inches of effective rooting depth.

Winona soils are used for livestock and big game range.

Representative profile of Winona gravelly loam, 0 to 10 percent slopes, in an area of native range, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 18, T. 16 N., R. 13 E., Coconino County:

A11—0 to 3 inches, brown (7.5YR 5/4) gravelly loam, dark brown (7.5YR 4/4) moist; weak, fine, platy structure and moderate, fine, granular and subangular blocky structure; soft, friable, slightly sticky and slightly plastic; many very fine and fine roots; many very fine interstitial pores; 20 percent gravel; very slightly effervescent; moderately alkaline (pH 8.2); clear, smooth boundary.

A12—3 to 9 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 4/4) moist; weak and moderate, fine and medium, subangular blocky structure; slightly hard, friable, slightly sticky and plastic; common very fine

and fine roots; many very fine and fine interstitial pores and few very fine and fine tubular pores; 5 to 10 percent lime gravel; strongly effervescent; moderately alkaline (pH 8.4); clear, smooth boundary.

Cca—9 to 17 inches, light-brown (7.5YR 6/4) gravelly loam, brown (7.5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and plastic; common very fine and fine roots; few fine tubular pores; 40 percent pebbles, limestone fragments, and cobblestones; pebbles are 15 to 30 percent fine, medium, and coarse lime nodules; strongly to violently effervescent; moderately alkaline (pH 8.4); abrupt, wavy boundary.

R—17 inches, limestone bedrock of the Kaibab Formation.

The depth to limestone is typically 10 to 18 inches, but ranges from 6 to 20 inches. The A horizon ranges from gravelly loam to gravelly light clay loam. It is of 10YR to 7.5YR hue; value is 4 or 5 dry and 3 or 4 moist, and chroma is 2 to 4. The A11 horizon is noneffervescent to strongly effervescent. It is 15 to 40 percent gravel. The C horizon is gravelly loam or gravelly light clay loam. It is of 10YR to 5YR hue. In some profiles, the C horizon is cobbly.

Winona gravelly loam, 0 to 10 percent slopes (WnC).—

This soil formed over limestone in the northeastern corner of the Area (fig. 19). Slopes are dominantly 4 percent or less, but range from 0 to 10 percent. Gravel covers 20 to 30 percent of the surface area, and scattered cobblestones, stones, and limestone outcrop cover less than 5 percent.

Included with this soil in mapping are areas of Tortugas soils, on convex ridges and sides of drainageways, that make up 10 percent of the total acreage. Also included are areas of soils at the higher elevations that have a weakly cemented limepan between depths of 18 and 26 inches; areas of Lynx soils in drainageways; and areas of Dye soils where the Coconino Sandstone abuts the Kaibab Limestone.

Runoff is slow to medium. The erosion hazard is low.

This Winona soil is in range herbage group 3, range improvement group 2, recreation group 3a, and capability subclass VIe dryland.

Formation and Classification of the Soils

This section describes the major factors of soil formation, tells how these factors have affected the soils in the Long Valley Area, and explains some of the principal processes in horizon development. It also defines the current system for classifying soils and shows how the soil of the Area are classified according to that system.

Factors of Soil Formation

Soil is more than a mixture of earth or rock material. Each soil is a product of the complex interaction of the effects of climate, plants, and animals on the parent material, modified by erosion, relief, and age of the landform. The importance of each factor differs from place to place, and each one modifies the other four. Even a small variation in one of the factors produces a different kind of soil. In the Long Valley Area there are variations in climate, parent material, relief, elevation, and kinds and numbers of living organisms. Soil-forming factors commonly vary within short distances. Consequently, many variations among the soils are evident.



Figure 19.—Winona gravelly loam, 0 to 10 percent slopes. This area has been cleared of juniper and seeded to grass.

Activities of man, such as logging and cattle grazing on the plateau country and farming at the lower elevations, have become a factor in soil formation. The cutting of the pine, the cultivation of the soils, and the prolonged use of the soils for grazing will probably influence the type and rate of soil formation. Few results of these practices can be seen in the soils today. Some may not be evident for many centuries. The balance of factors that affect soil genesis has been changed, however, as a result of man's activities.

Parent material

The parent material of the soils in the Long Valley Area are basic igneous rock, sedimentary rock, and unconsolidated deposits. The soils on the uplands formed in residuum weathered from various kinds of rock, and the valley fill and terrace soils formed in mixed alluvial sediments that were originally upland soils and rocks.

Basalt and other volcanic material are common in the Area and range in thickness from only a few feet to hundreds of feet. Broliar, Cabezon, Gem, Graham, House Mountain, Siesta, and Springerville soils formed in residuum weathered from basalt. Many soils derived from basalt are cobbly and stony because basalt resists weathering. Montmorillonite clay, which has a high shrink-swell potential, is prevalent in the soils derived from basalt.

All of the basalt-derived soils but House Mountain have a distinct clay B horizon. Residuum weathered from cinders is the parent material of the Sponseller, Waldroup, and some of the Siesta soils and accounts for the distinct, reddish-brown and red colors of these soils.

An extensive area above the Mogollon Rim is Kaibab Limestone. Residuum weathered from this limestone is the parent material of the Hogg, Soldier, Tortugas, and Winona soils. Hogg and Soldier soils are deep over bedrock, have moderately to strongly expressed horizons, and have an appreciable accumulation of clay in the subsoil. Tortugas and Winona soils are shallow over bedrock and have weakly expressed horizons. Part of the contrast in the profiles of these soils can be attributed to lithological differences within the rock formations. Verde Limestone is the parent material of the stony, shallow Retriever soils that are in areas below the Mogollon Rim.

Sandstone is the parent material of some of the soils in the Area. Residuum weathered from the resistant, hard Coconino Sandstone is the parent material of the shallow, stony Dye, Palomino, Sanchez, Jacks, and Wildcat soils. The rock outcrop associated with Dye, Palomino, and Sanchez soils is evidence of the weathering resistance of the Coconino Sandstone. Jacks and Wildcat soils have distinct horizons. A sandstone, or sandy member of the Kaibab Formation, is the parent material of McVickers

soils. Chilson soils formed in material derived from Moenkopi Sandstone and were influenced by a shale member of the Moenkopi Formation.

Old valley fills, old terrace deposits, and more recent alluvial and colluvial deposits contain mixtures of parent materials that vary widely in composition and texture. Cornville, Overgaard, Penthouse, and Rimrock soils formed in fill that was strongly influenced by basalt. Horizon expression is distinct in Cornville, Overgaard, and Penthouse soils, but is weak in the churning and cracking Rimrock soils.

Sediment derived from basalt and cinders is fine textured, as evidenced by the clay texture of the Friana soils. The loamy Clover Springs soils on the other hand, formed in sediment of limestone and sandstone. The Hantz and Navajo clays retain the fine texture of their alluvial, shaly parent material. The calcareous Glendale and Guest soils formed in alluvium weathered from the Verde Limestone. Anthony, Arizo, and Cowan soils formed in sandy, gravelly, and cobbly alluvial deposits.

Plants and animals

Both plants and animals affect the formation of soil. Vegetation adds organic matter to the soil and modifies its structure and physical condition. Animals mix the soil by burrowing beneath the surface. The horizon most significantly affected by living organisms is the A1 horizon.

Soils in the Long Valley Area formed under three types of vegetation: ponderosa pine, pinyon-juniper, and grassland-desert shrub. The vegetative types generally occur in a pattern that is controlled by temperature, amount of precipitation, and elevation.

Most of the soils that formed under ponderosa pine have a dark-colored A1 horizon, 4 to 9 inches thick, that has a granular structure and a reaction that ranges from medium acid (pH 5.9) to mildly alkaline (pH 7.6). In many of these soils the dark color extends into the B1 and B2 horizons. McVickers, Sanchez, Soldier, and Wildcat soils formed under ponderosa pine, but do not have a dark-colored surface layer. The soils under ponderosa pine are not calcareous.

Soils that formed under pinyon pine and juniper, or on the fringe of the ponderosa pine forest, have a dark-colored A1 horizon similar to that of the soils that formed under ponderosa pine. Horizons are thinner, however, and the reaction ranges from neutral (pH 7.0) to moderately alkaline (pH 8.4). Some of these soils are calcareous.

The soils that formed in the grassland-desert shrub areas are light colored and are ordinarily moderately alkaline (pH 7.9 to 8.4).

Soils under ponderosa pine have a 1- to 2-inch layer of surface litter that has a high organic-matter content. In years of normal needle fall, the air-dry weight of the added litter is approximately 5 to 8 tons per acre. Soils in the pinyon-juniper woodland commonly have little or no surface litter. Soils under grassland-desert shrub vegetation have no measurable litter and have an organic-matter content of about one-half to 1 percent.

In the ponderosa pine zone, the needle litter is evenly distributed because the canopy is uniform and the trees are tall. In the pinyon-juniper woodland, the litter is

concentrated within the drip zone under the trees. Grass and weeds are the main source of organic matter in the grassland-desert shrub zone.

Vegetation not only adds organic material to the soils, but also modifies the influence of climate on the soils. Shade and layers of litter reduce evaporation and help retain the supply of available moisture. The soil temperature under a dense stand of trees is much cooler than that under a sparse or open stand. This difference in temperature is significant in forest areas.

Relief

Relief influences soil formation through its effect on climate, drainage, erosion, and vegetation. Most of the Long Valley Area is gently sloping or undulating and rolling, but some parts are steep. Cliffs, escarpments, and rims are prominent on the landscape. The elevation, which ranges from about 3,000 to about 8,500 feet, influences the temperature and precipitation. As the elevation increases, the average annual temperature decreases and the average annual precipitation ordinarily increases. These changes in temperature and precipitation strongly influence the kind and amount of vegetation.

The combined effects of relief, precipitation, temperature, and vegetation are clearly evident in the Long Valley Area. Most of the soils that show signs of intensive weathering, such as considerable depth over bedrock and strong structure in the subsoil, are on the plateau above the Mogollon Rim where elevations are 6,500 to 8,500 feet. The relief in this area is gentle, the precipitation is high, and the vegetative growth, particularly conifers, is dense and heavy. Broliar, Friana, Hogg, McVickers, Overgaard, Siesta, and Soldier soils are on the plateau. The steeper, shallower, less strongly developed soils within the ponderosa pine forest are on the tops and sides of ridges where runoff is rapid and soil is lost through erosion. Chilson and Tortugas soils are examples.

Soils on bottom land or in swales and depressions receive considerable runoff from higher areas. The runoff waters deposit sediment that is high in organic-matter content. As a result, organic material accumulates in the profile of these soils. Clover Springs and Lynx soils are examples of soils that were influenced in their formation by relief. Both have received accumulations of sediment from higher lying soils.

Normally in mountainous areas, soils on north-facing slopes weather more rapidly than those on south-facing slopes because more moisture is available and they are more deeply leached. Even though vegetation is denser on some north-facing slopes in the survey area than on adjacent south-facing slopes, the soils do not differ significantly because slopes are short and not very steep. Moreover, many steep areas are at low and medium elevations where aspect has less effect on the microclimate and soil formation.

Time

The age of a soil can be judged, in part, by the depth to which the soil has weathered, the degree of horizonation, the intensity of weathering and leaching, and the kind and amount of clay accumulation in the profile. The effect of time as a factor in soil formation depends on

the influences exerted by climate, living organisms, relief, and parent material. The strength of these influences depends, in turn, upon the length of time each of the other soil-forming factors has been at work. These periods of time may be centuries or millennia, but it is usually more than just a few years.

Most soils on uplands in the Long Valley Area have distinct horizons. Some, McVickers and Soldier soils for example, have a thick, distinct A2 horizon underlain by a thick, clay B2 horizon. Formation of these soils, which have such strong evidence of translocation of silicate clay minerals and iron compounds, probably required an extremely long period of time. It is likely that for a part of that time the climate was more humid than it is now. Other soils that formed distinct horizons in which clay has accumulated and that show other evidence of weathering and leaching over long periods of time are Jacks, Hogg, Broliar, Siesta, and Sponseller soils. The presence of clay horizons in Cornville and Penthouse soils, which receive little rainfall, indicates a long period of stability of the landform on which they formed.

Many landforms in the Area, particularly those above the Mogollon Rim, have been stable for a long time. The Mogollon Rim appears to have been in existence in the mid-Tertiary period, and, except for deeper stream channels and retreated canyon walls, it is much the same today as it was 3 to 4 million years ago. The vast quantity of volcanic material in the Area is also believed to date to the Tertiary period.

The young soils in the Area are mostly those that formed in recently deposited alluvium or in material weathered from strongly calcareous material. They lack a distinct B horizon, are commonly calcareous to the surface, and show little accumulation of clay in the profile. Examples are Anthony, Glendale, Guest, Hantz, and Cowan soils that formed in recent alluvium; Tortugas and Winona soils that formed in residuum weathered from limestone; and House Mountain soils that formed in residuum weathered from basalt.

Climate

The climate in the Long Valley Area is continental and ranges from arid to subhumid. It is strongly influenced by elevation, which ranges from 3,000 to 8,500 feet. At the higher elevations, the weather is cold in winter and warm in summer. At the lower elevations, the weather is usually mild throughout the year. Diurnal and seasonal changes in the temperature are less pronounced than at the higher elevations. The warm, sunny weather that is usual throughout the year favors the chemical reactions that are essential in soil formation, but the rate and intensity of the reactions depend on the amount of moisture that is available. Moisture conditions are more favorable in the ponderosa pine zone and in the higher parts of the pinyon-juniper zone than in the grassland-desert shrub zone.

At the higher elevations, annual precipitation of 20 inches is common. Much of it falls as snow, and in years of normal snowmelt, the soils absorb most of the moisture. The organic-matter content is higher than in soils at lower elevations, and horizon development is more pronounced.

At the lower elevations, annual precipitation seldom exceeds 15 inches. It usually falls as intense, violent rainstorms, and most of the water is lost through runoff. The organic-matter content of the soils is low, and horizons are not clearly expressed.

The effect of the climate on soil formation in the Area is evident in the Hogg and the Retriever soils. Both formed in residuum weathered from limestone. Hogg soils, which are at the high elevations, receive about 20 inches of precipitation per year. The water has leached lime down below a depth of 20 inches, clay has accumulated in the subsoil, and distinct horizons that have structural development have formed. In contrast, Retriever soils receive only about 10 inches of precipitation per year. The lime has not been entirely removed from any part of the profile, and no clay has accumulated to form distinct horizons.

Leaching of bases and other soluble material and translocation of colloids generally increase as the amount of precipitation increases. Weathering and translocation of soil material are further intensified by alternating periods of freezing and thawing and of wetting and drying. In normal years, the soils at the higher elevations are frozen to a depth of several feet in winter, but freezing and thawing may occur several times each year. The temperature at the lower elevations is seldom below freezing.

Representative Soil Horizons

The action of the soil-forming factors is reflected in the soil profile, which is a succession of horizons, or layers, from the surface down to unaltered parent material or bedrock. The horizons differ in one or more properties, such as color, texture, thickness, structure, consistency, porosity, and reaction.

The major horizons in the soils of the Area are mollic and ochric epipedons, and albic, argillic, and calcic horizons.

About one-third of the soils have a mollic epipedon, or a somewhat thick, dark-colored surface mineral horizon that is at least 1 percent organic matter. The rest of the soils have an ochric epipedon, which is either too light in color, too high in chroma, too low in organic-matter content, or too thin to be a mollic epipedon.

An albic horizon, or an A2 horizon, is one from which clay and free iron oxide have been removed. It is typically light colored. McVickers, Overgaard, Sanchez, Soldier, and Wildcat soils have an albic horizon.

An argillic horizon is typically a subsoil, or B horizon, that has an appreciable accumulation of silicate clay minerals. The clay films on the surface of the peds indicate a downward movement of clay from the epipedon, or A horizon, mainly through the percolation of water. Nearly all of the 21 soils in the Area that have an argillic horizon are above the Mogollon Rim.

Some soils in the Area lack an argillic horizon. The letter "C" is used to designate the horizon below the epipedon in these soils.

Bridge and Cornville soils have a calcic horizon, or one in which lime has accumulated. Disterheff, Gem, and Penthouse soils have a horizon that is limy, but not limy enough to qualify as a calcic horizon.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (2) and revised later (6). The system currently used by the National Cooperative Soil Survey was developed in the early sixties and was adopted in 1965 (8). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available. Table 3 shows the classification of each soil series of the Long Valley Area by family, subgroup, and order, according to the current system. Brief descriptions of the six categories follow.

Order.—Ten soil orders are recognized: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate orders are those that tend to give broad climatic groupings of soils. Two exceptions to this generalization are the Entisols and the Histosols, both of which occur in many different climates. Five of the ten orders are represented in the Long Valley Area: Entisols, Vertisols, Aridisols, Mollisols, and Alfisols.

Entisols are young soils that show little, if any, alteration of the parent material. No significant illuviation, eluviation, or extreme weathering is evident in the profile of the Entisol.

Vertisols are clayey soils that swell when wet and shrink and crack widely when dry.

Aridisols are soils of dry regions. For prolonged periods they hold little or no water available for plants.

Mollisols have a thick, dark-colored surface layer that has moderate or strong structure and contains an appreciable amount of organic matter.

Alfisols have been in place long enough for the movement and accumulation of silicate clays within the soil profile. They are characterized by a massive, hard surface layer and by horizons of clay accumulation that have high base saturation. Base saturation at a depth of 6 feet is more than 35 percent.

Suborder.—Each order is divided into suborders, mainly on the basis of soil characteristics that result in grouping soils according to genetic similarity. The climatic range is narrower than that of the order. The properties used are mainly those that reflect either the

presence or absence of waterlogging or differences in climate or vegetation. In the Long Valley Area, Entisols are separated into two suborders: Fluvents and Orthents.

Fluvents are not permanently saturated with water. They consist of recent alluvium that is stratified. The stratification of the Fluvents, then, distinguishes them from very young soils that have no horizons.

Orthents are soils on recently eroded slopes, where soil material is removed by erosion almost as fast as it forms.

Great group.—Each suborder is divided into great groups on the basis of similarity in the kind and sequence of the major horizons and in major soil properties. The horizons considered are those in which clay, iron, or humus have accumulated and those in which pans that interfere with the growth of roots and the movement of water have formed. The properties are soil temperature, chemical composition (mainly content of calcium, magnesium, sodium, and potassium), and the like.

Subgroup.—Each great group is divided into subgroups, one that represents the central (typic) concept of the group, and others, called intergrades, that have one or more properties of another great group, suborder, or order.

Family.—Families are established within each subgroup, primarily on the basis of properties important to the growth of plants or properties significant in engineering. Texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence are among the properties considered.

Series.—A series is a group of soils that have horizons similar in all important characteristics, except for texture of the surface layer, and similar in arrangement in the profile.

The distribution of the soil orders in the Area is influenced markedly by relief through its effect on climate and vegetation. Of the nine Entisols, only Navajo and Winona soils are on the plateau above the Mogollon Rim. All the Aridisols are below the Rim. Of the Vertisols, Rimrock soils are below the Rim and Springerville soils are mostly above the Rim. Only two of the twelve Mollisols, Graham and Guest soils, are below the Rim. All the Alfisols are on the plateau above the Rim. Most of the Mollisols and all of the Alfisols, but Disterheff, Dye, and Waldroup soils, are within the ponderosa pine zone.

Fluvents are very young Entisols on flood plains and in drainageways. The carbonatic families of the Orthents, Retriever, and Winona soils reflect limestone parent material and lack of leaching.

The two Argids, Cornville and Penthouse soils, reflect long-term stability of the landforms on which they formed.

Differences in soil temperature of the Vertisols are shown in the thermic family for Rimrock soils and the mesic family for Springerville soils.

The pachic and cumelic subgroups, represented by Clover Springs, Friana, and Lynx soils, indicate a thick mollic epipedon. Clover Springs and Lynx soils occupy drainageways. Their thick surface horizon probably can be attributed to the additional organic material in sediment deposited by streams. The nearly level Friana soils formed in depressions. They receive runoff but little

TABLE 3.—*Soil series classified according to the current system of classification*

Series	Family	Subgroup	Order
Anthony.....	Coarse-loamy, mixed (calcareous), thermic.....	Typic Torrifluvents.....	Entisols.
Arizo.....	Sandy-skeletal, mixed, thermic.....	Typic Torriorthents.....	Entisols.
Bridge.....	Fine-loamy, mixed, thermic.....	Typic Calciorthids.....	Aridisols.
Broliar.....	Fine, montmorillonitic.....	Argic Cryoborolls.....	Mollisols.
Cabazon.....	Clayey, montmorillonitic, mesic.....	Lithic Argiustolls.....	Mollisols.
Chilson.....	Clayey, mixed.....	Lithic Argiborolls.....	Mollisols.
Clover Springs.....	Fine-silty, mixed.....	Cumulic Cryoborolls.....	Mollisols.
Cornville.....	Fine-loamy, mixed, thermic.....	Typic Haplargids.....	Aridisols.
Cowan.....	Sandy, mixed, thermic.....	Typic Torrifluvents.....	Entisols.
Disterheff.....	Fine, montmorillonitic, mesic.....	Typic Haplustalfs.....	Alfisols.
Dye.....	Clayey, mixed, mesic.....	Lithic Haplustalfs.....	Alfisols.
Friana.....	Fine, montmorillonitic.....	Argic Pachic Cryoborolls.....	Mollisols.
Gem ¹	Fine, montmorillonitic, mesic.....	Typic Argiustolls.....	Mollisols.
Glendale.....	Fine-silty, mixed (calcareous), thermic.....	Typic Torrifluvents.....	Entisols.
Graham.....	Clayey, montmorillonitic, thermic.....	Lithic Argiustolls.....	Mollisols.
Guest.....	Fine, mixed, thermic.....	Cumulic Haplustolls.....	Mollisols.
Hantz.....	Fine, mixed (calcareous), thermic.....	Typic Torrifluvents.....	Entisols.
Hogg.....	Fine, mixed.....	Mollic Eutroboralfs.....	Alfisols.
House Mountain.....	Loamy, mixed, nonacid, thermic.....	Lithic Torriorthents.....	Entisols.
Jacks.....	Fine, mixed, mesic.....	Udic Haplustalfs.....	Alfisols.
Luth.....	Fine, mixed.....	Typic Cryoborolls.....	Mollisols.
Lynx.....	Fine-loamy, mixed, mesic.....	Cumulic Haplustolls.....	Mollisols.
McVickers.....	Fine, montmorillonitic.....	Typic Cryoboralfs.....	Alfisols.
Navajo.....	Fine, mixed (calcareous), mesic.....	Typic Torrifluvents.....	Entisols.
Overgaard.....	Fine, mixed.....	Typic Cryoboralfs.....	Alfisols.
Palomino.....	Loamy, mixed.....	Lithic Cryoboralfs.....	Alfisols.
Penthouse.....	Fine, mixed, thermic.....	Ustollic Haplargids.....	Aridisols.
Retriever.....	Loamy, carbonatic, thermic.....	Lithic Torriorthents.....	Entisols.
Rimrock.....	Fine, montmorillonitic, thermic.....	Typic Chromusterts.....	Vertisols.
Sanchez.....	Loamy-skeletal, mixed.....	Lithic Eutroboralfs.....	Alfisols.
Siesta.....	Fine, montmorillonitic.....	Mollic Cryoboralfs.....	Alfisols.
Soldier.....	Fine, montmorillonitic.....	Glossic Cryoboralfs.....	Alfisols.
Sponseller.....	Fine-loamy, mixed.....	Argic Cryoborolls.....	Mollisols.
Springville.....	Fine, montmorillonitic, mesic.....	Typic Chromusterts.....	Vertisols.
Tortugas.....	Loamy-skeletal, carbonatic, mesic.....	Lithic Haplustolls.....	Mollisols.
Waldroup.....	Fine, montmorillonitic, mesic.....	Udic Rhodustalfs.....	Alfisols.
Wildcat.....	Fine, montmorillonitic.....	Aquic Eutroboralfs.....	Alfisols.
Winona.....	Loamy, carbonatic, mesic.....	Lithic Torriorthents.....	Entisols.

¹ The Gem soils in the Long Valley Area are taxadjuncts to the Gem series. They are outside the defined range of the series because the control section is not dry for as long as 45 consecutive days in 6 out of 10 years following the summer solstice. Similar kinds of soils were named Gem in the recently published soil survey of Beaver Creek Area, Arizona, and also have been correlated as Gem soils in the Zuni Mountain Area. The name Gem is used in this Area to provide uniformity of nomenclature with that of the adjacent Beaver Creek Area and Zuni Mountain Area surveys.

sediment from higher lying soils. Their thick, dark-colored surface horizon probably can be attributed to the extra moisture and increased plant growth.

The lithic subgroups denote soils that are shallow over bedrock.

Soil temperature in the Area corresponds closely with the vegetation zones. Soils grouped in the thermic family are in the grassland-desert shrub zone. Those in the mesic family are largely in the pinyon-juniper zone. Soils in the frigid family are in the ponderosa pine zone.

Part III: Land Management

The lands of the National Forest System in the Long Valley Area are managed under the principles of multiple use and sustained yield. Planning for these activities involves full consideration of the potential and limitation of the soil in the management of both single resources or combinations of resources.

Land management in this survey is suggested by soil management areas. Each management area consists of

either a single dominant soil, or two or three dominant soils that occur together with some regularity of pattern. Individual soils within a soil management area may differ markedly from each other, but their pattern of distribution varies little. Each of the soil management areas contains less extensive soils that are not included in the name of the area.

Soil Management Areas

The 10 soil management areas in the Long Valley Area are shown on the general soil map at the back of this survey. A map of soil management areas is useful to people who want a general idea of the soils in the entire survey area. It cannot be used effectively for intensive planning or for planning management of small areas. It is useful as a general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. The soil management areas are described on the pages that follow. Unless otherwise stated, the soil texture mentioned is the weighted average texture be-

tween depths of 10 and 40 inches or, if the soil is shallower than 20 inches, between the surface and bedrock. For more detailed information about the soils, see the detailed soil map and the section "Descriptions of the Soils."

1. Siesta-Sponseller soil management area

This area is on the Coconino Plateau, above the Mogollon Rim. It occurs as a succession of small, scattered tracts in an almost direct line from Baker Butte in the extreme south to the northern boundary of the survey area.

This management area is 9,948 acres in size and makes up about 2 percent of the total land area. It is about 75 percent Siesta soils and 25 percent Sponseller soils.

The landscape is one of undulating, rolling uplands and cinder cones. The areas of Siesta and Sponseller soils surround the cinder cone buttes. Slopes are dominantly 5 to 10 percent, but range to as much as 40 percent on the sides of the cinder cones. The elevation ranges from 6,700 to 8,400 feet. The vegetation is mainly ponderosa pine and mixed grasses, scattered Gambel oak, and, at the higher elevations, some Douglas-fir.

The soils in this area formed in residuum weathered from basalt and volcanic cinders. Siesta soils have a loam and cobbly loam surface layer and a clay subsoil. Sponseller soils have a gravelly silt loam surface layer and a clay loam subsoil. The depth to bedrock ranges from 30 to 72 inches.

This area is one of the most productive in the Long Valley Area. The potential for timber production is high. Growth of ponderosa pine is vigorous, and natural regeneration is good. The potential for production of range herbage is moderately high. Open areas support good stands of grass. Sponseller soils have higher site index values than Siesta soils, but both soils are well suited to ponderosa pine and both produce more range herbage than the soils of the Broliar soil management area.

Engineering qualities of the soil vary. The soils are typically high in clay content and have low compacted weight. Consequently, roads designed for all-weather travel require surfacing. Sites for stock tanks must be carefully selected. Some soils in this area are less than 40 inches deep over cinders or pervious gravel. Most are a source of cinders suitable for road surfacing.

2. Broliar soil management area

This is an area of about 96,487 acres, and it makes up about 15 percent of the Long Valley Area. It is 95 percent Broliar soils and 5 percent Chilson soils.

The landscape is one of undulating uplands broken by ridges, canyons, and small drainageways. The steep soils are on the sides of Blue Ridge. The slope gradient is dominantly less than 10 percent, but ranges to as much as 45 percent. The elevation is about 6,700 to 7,400 feet. The vegetation is mainly ponderosa pine and mixed grasses and scattered Gambel oak and alligator juniper.

Broliar and Chilson soils have a very firm, sticky and very plastic clay subsoil. They formed mainly in residuum weathered from basalt. In a small part of the area, they

tial for range herbage and timber production is only medium. Grasses grow well throughout the entire area. Trees grow faster and are of better quality for timber at the higher elevations. Natural regeneration of pine is good at the higher elevations. Deer, elk, and turkey inhabit the area.

The degree of erosion varies. Depletion of forage is most likely to result in loss of surface soil through erosion. A few shallow gullies have formed in old roads. The hazard of erosion can be reduced by increasing the density of the plant cover.

These soils have a high clay content and low compacted weight. They are hard to handle and work because the clay is sticky and very plastic. Unsurfaced roads become soft and sticky and are nearly impassable during wet periods. Ruts formed by vehicles when the soils are wet do not disappear after they dry. Suitable sites for stock tanks or ponds are available in all but the very stony, very rocky, and steep soils.

3. Luth-Clover Springs soil management area

This area, the smallest, is 5,282 acres in size and makes up about 1 percent of the survey area. It is about 40 percent Luth soils, 40 percent Clover Springs soils, and 20 percent Friana soils.

This management area is one of open parks, narrow valleys, and drainageways. It occurs in both the ponderosa pine forest and the pinyon-juniper woodland. Elevation ranges from 6,700 to 7,700 feet.

The Luth soils formed mainly in sediment weathered from limestone and sandstone, and the Friana soils formed in sediment derived mainly from cinders and basalt. These soils are sandy loams, loams, silt loams, clay loams, and clays. The surface area is mostly free of significant amounts of coarse fragments, but in some areas there are thin strata of gravel beneath the surface.

The soils of this management area are considered poor to unsuitable for timber production, but they are among the best for herbage production. In most places they hold about 10 inches of water available to plants. In places, the water table is as high as 4 feet.

Clover Springs and Luth soils are extensively gullied. In many areas, gullies and head cuts have lowered the water table of the Clover Springs soils to such an extent that production of range herbage has decreased and the surrounding upland forests have begun to spread to the bottom land. The depletion of forage grasses has increased the hazard of erosion. Most of the area is eroded. The hazard of sheet and gully erosion can be reduced by increasing the density of the plant cover.

This area provides suitable sites for stock tanks and ponds. It is used chiefly for summer grazing of livestock and as a source of food for wildlife. Reseeding in selected areas would be desirable. Both reseeding and erosion control would be needed in gullied areas. Small check dams could help stabilize the gullies and restore the level of the water table. Dams should be well secured to abutments and designed to handle overflow in order to prevent gullving around the ends of the dams.

parts of the survey area. It is 160,163 acres in size and makes up about 25 percent of the survey area. It is 45 percent Springerville soils, 30 percent Gem soils, 20 percent Cabezon soils, and about 5 percent Disterheff and Waldroup soils.

The terrain is uplands and mesas. Slopes are dominantly less than 10 percent. Natural drainageways are shallow, and the sides are short and smooth. Elevation ranges from 4,200 to 7,000 feet. The overstory is juniper. The understory is grass.

Springerville, Gem, Disterheff, and Waldroup soils are cobbly, gravelly, and stony. Cabezon soils are stony and cobbly, are shallow over bedrock, and occupy convex ridges. Gravel, cobblestones, and stones typically cover 15 to 40 percent of the surface area. Some of the soils have an appreciable number of stones and cobblestones throughout the profile.

These clay soils are extremely difficult to work and handle. The high shrink-swell potential makes them unsuitable for engineering structures. Unsurfaced roads become soft and sticky and nearly impassable during wet periods. Loss of soil through erosion is negligible in most places, but in some areas of Waldroup soils, gullies are active.

These soils are not suitable for timber. They are used chiefly as livestock range and wildlife feeding areas. All but the very stony, cobbly, and gravelly soils provide suitable sites for tanks and ponds. Range herbage production is moderately high, and browse production is moderate. Juniper control and reseeding would improve the area for livestock and attract game. Improving range and wildlife herbage and increasing the supply are the chief management needs.

5. Soldier-McVickers soil management area

This area is chiefly on the Coconino Plateau in the southeastern quarter of the survey area. It is 104,721 acres in size and makes up about 17 percent of the survey area. It is about 60 percent Soldier soils, 30 percent McVickers soils, 5 percent Hogg soils, and 5 percent Overgaard soils and Limestone rock land.

The landscape is one of nearly level to steep uplands broken by a series of ridges, deep canyons, and drainageways. Slopes are dominantly less than 10 percent, but range from 0 to 60 percent. The elevation ranges from 6,800 to 8,000 feet. The vegetation is a dense stand of ponderosa pine and a grass understory.

Most of the surface area of Soldier soils is covered with chert gravel and cobblestones. For the most part, the soils in this area are loams and sandy loams over reddish clay and are more than 42 inches deep over bedrock. The Soldier, McVickers, and Hogg soils formed in residuum weathered from limestone and sandstone. The Overgaard soils formed in gravelly old alluvium.

These are among the most productive soils in the Area for timber and grass and among the most productive soils in the State for ponderosa pine. About half of the management area is in timber group 1, and the other half is in group 2. Site-index values for ponderosa pine range from about 70 to more than 80. Natural regeneration is good to very good on most of the soils and fair on the more stony soils. Potential for herbage production is

moderate to high. In many places, the canopy is dense and the herbage is sparse.

Most of this area is only fair for browse because ponderosa pine has a high rate of regeneration and tends to crowd out browse species. The many mature and overly mature aspen are not usable as wildlife forage. Wildlife openings are needed. They are difficult to maintain except in some of the narrow drainageways in areas of Clover Springs soils.

In addition to being important for timber, this area is important for water yield. It is the highest precipitation zone in the survey area. The available water capacity is high, and the infiltration rate is good. Thus, these soils are able to store and release water to streams and springs during most of the year. Most of the major drainageways in the Long Valley Area originate in this management area.

The erosion hazard is slight to moderate. Roads constructed on these soils, especially those that contain many chert fragments, require little maintenance and can generally handle all-weather traffic. Stock tanks and ponds are watertight if the bottoms and sides are the clay subsoil. The surface soil is fair embankment material.

This area has limited value for use as wildlife habitat and summer livestock range, but a high potential for development of recreation sites.

6. Hogg-Jacks-Wildcat soil management area

This is an area of 55,869 acres, and it makes up about 9 percent of the survey area. It is about 30 percent Hogg soils; 20 percent Jacks soils; 20 percent Wildcat soils; and about 30 percent Tortugas soils, Palomino soils, and rock outcrop.

The landscape is one of nearly level to steep uplands. Slopes are dominantly less than 10 percent, but range from 0 to 45 percent. Considerable interbedding of sandstone causes abrupt differences in the soils and relief. Elevation ranges from 6,400 to 7,800 feet. The vegetation is ponderosa pine, pinyon, juniper, Gambel oak, cliffrose, grasses, and forbs.

The soils are dominantly gravelly and stony clays, clay loams, and sandy clay loams. They are among the stoniest in the survey area. The stone cover and the stone content range from less than 5 percent to more than 60 percent. Stones are more abundant on the surface of the steeper soils than on the gently sloping soils. The level soils are typically deeper than 50 inches. Most of the steep soils are about 30 inches deep. Reaction is dominantly neutral to mildly alkaline, but ranges from slightly acid to moderately alkaline.

This area has an abundance of Gambel oak and a few shrubs and forbs and has a fair potential for big game browse. Gambel oak sprouts prolifically in recently logged areas. Herbage production potential ranges from low to moderate. Timber production potential is medium to low. Site-index values are dominantly 55 to 60, but range from less than 50 to as high as 70. Natural regeneration of pine is fair to poor.

Suitable sites for the construction of stock tanks are available in all but the stony and rocky soils and in the shallow soils near the Rim in the southern part of the Area. The soils are generally poor road construction material, but some areas of the underlying limestone have

weathered sufficiently to be easily crushed and used as subgrade material. The soils are highly erodible, and unsurfaced roads are difficult to maintain. The erosion hazard is moderate to high. Sheet erosion is moderate, and numerous shallow gullies have formed in unsurfaced roads. The stoniness, high clay content, and shallowness of these soils make campsites and recreation areas difficult to maintain and keep vegetated.

This area is used for timber, summer livestock grazing, and wildlife. It has limited value for timber production, and in most places the soils are not suited to conventional plantation methods. This area would provide excellent habitat for wildlife if suitable browse species were introduced. It is widely used for fall feeding and is generally accessible throughout the fall season.

7. Tortugas-Winona-Retriever soil management area

This is an area of 50,616 acres, and it makes up about 8 percent of the survey area. It is about 40 percent Tortugas soils; 30 percent Winona soils; 20 percent Retriever soils; and about 10 percent Dye, Lynx, and Navajo soils. These soils are mostly less than 20 inches deep over bedrock. Tortugas and Winona soils are above the Mogollon Rim in the extreme northeastern part of the survey area, at elevations of 6,200 to 6,800 feet. Retriever soils are below the Rim in the northwestern part of the survey area, at elevations of 3,100 to 4,100 feet.

The landscape is gently sloping to hilly and is cut by shallow drainageways and a few canyons. Slopes are short. The quantity of gravel, stones, and cobblestones commonly increases with increasing slope gradient. The bedrock is dominantly limestone, but in some areas there are domelike outcrops of sandstone. The vegetation is Utah juniper, pinyon, and cliffrose at the higher elevations. Canotia, creosotebush, and cholla grow at the lower elevations.

Tortugas, Winona, and Retriever soils are commonly of loam texture modified by varying amounts of gravel, cobblestones, and stones and are 8 to 18 inches deep over limestone. Dye soils are sandy clay loams or clays about 10 to 20 inches deep over sandstone. Lynx and Navajo soils are clay loams and clays that are commonly more than 50 inches deep over bedrock.

The available water capacity is 7 to 12 inches in the Lynx and Navajo soils and is less than 4 inches in the rest. The potential for revegetation and for range herbage production is low. The area is not suitable for timber. Loss of soil through erosion has been slight in most places, but Lynx and Navajo soils have extensive gullies 3 to 6 feet deep.

Shallowness over bedrock limits the use of the soils in this area for installation of drainage systems and stock tanks and for other deep excavations. The underlying limestone can be crushed and used as road material.

This area is used chiefly as livestock range and wildlife habitat. The part atop the Coconino Plateau is an important winter feeding area for wildlife. Increasing and improving range and wildlife herbage are the chief management needs.

8. Graham-House Mountain soil management area

This area, 30,047 acres, makes up about 5 percent of the survey area. It is 45 percent Graham soils, 30 percent

House Mountain soils, 10 percent Bridge soils, and 15 percent Penthouse and Rimrock soils. These soils are on uplands and old alluvial fans and terraces below the Mogollon Rim, where the elevation is 3,000 to 4,000 feet. In most areas they are gently to moderately sloping, but in some they are steep. They are about 4 to 20 inches deep over basalt and are stony, cobbly, and gravelly. They formed chiefly in residuum weathered from basalt and in alluvium derived from basalt, tuff, and volcanic ash.

The Bridge soils in this area are sandy loams and sandy clay loams that are about 22 to 36 inches deep over tuff and volcanic ash. The Penthouse and Rimrock soils are gravelly and cobbly clays that are 24 to 60 inches deep over bedrock.

The vegetation is semidesert shrubs, such as canotia, mesquite, and catclaw; grasses, such as blue grama, black grama, side-oats grama, and tobosa; and, at the higher elevations, juniper. About half of this area is barren.

These soils receive insufficient rainfall to support ponderosa pine, and their potential for herbage production is low. The available water capacity is less than 3 inches. Loss of soil through erosion is moderate to low. There are a few small gullies. Shallowness over bedrock limits the use of these soils for deep excavations, drainage systems, stock tanks, and roads. The large number of stones and cobblestones makes these soils difficult to work. The Penthouse, Graham, and Rimrock clays have a high shrink-swell potential and are extremely poor construction material.

These soils are best suited to use as range for livestock and game. Management should be directed toward improving the quality and quantity of forage through controlled grazing and revegetation of barren areas.

9. Glendale-Anthony soil management area

This is an area of 4,411 acres, and it makes up about 1 percent of the survey area. It is about 40 percent Glendale soils; 15 percent Anthony soils; and 45 percent minor areas of Cornville, Guest, Hantz, Cowan, and Arizo soils. These soils are on flood plains, low terraces, and alluvial fans in the Verde Valley, at elevations of 3,100 to 4,000 feet. They are nearly level to gently sloping and are dominantly more than 60 inches deep over bedrock. They formed in alluvium weathered from limestone, sandstone, shale, basalt, and other rock. In most places they are calcareous to the surface. In some, the surface area is covered with gravel. The vegetation is dominantly creosotebush, mesquite, canotia, catclaw, galleta, tobosa, and grama. Cottonwood, sycamore, and willow grow on the bottom land.

These soils have a moderately high potential for herbage production and a moderate potential for revegetation. They receive additional moisture as runoff from the surrounding slopes.

A large part of this area shows the effects of erosion by water. Gullying is severe. In areas of Glendale and Guest soils, gullies are as much as 10 feet deep. Erosion by wind is apparent in some localities.

These soils can be easily excavated and worked throughout a wide range of moisture content. The Arizo soils are good material for road fill.

Most of this area is privately owned, and is used mainly for livestock grazing and homesites. Revegetation and

careful management can improve the area for livestock, increase the yield of herbage, and help to control erosion.

10. *Stony rough land-Rock land management area*

This area, 109,079 acres, makes up about 17 percent of the survey area. It is about 41 percent Basalt rock land, 30 percent Limestone and sandstone rock land, and 20 percent Stony rough land, ash and tuff. The landscape is one of steep to very steep rock outcrops, cliffs, and escarpments. The elevation ranges from 3,400 to 7,800 feet. The vegetation is dominantly ponderosa pine, Douglas-fir, pinyon pine, juniper, mesquite, pricklypear, cholla, and canotia.

This area supports a small amount of herbage, but most of it is unsuitable for grazing. The area is used mainly as wildlife habitat and as a source of runoff following heavy summer rain. Only a small amount of timber is grown; none is harvested.

The spectacular, nearly vertical, multicolored walls of East and West Clear Creeks are scenic. The steep sides of the canyons are natural barriers to the spread of wild-fire. The clifflike walls of the many deep gorges present problems in road design and construction.

Timber Management

About 43 percent, or 267,025 acres, of the Long Valley Area is commercial timberland. The commercial forests are at elevations of 6,400 to 8,500 feet.

Saw-log harvest began in the Area in the late 1940's. The last cutting of virgin timber stands began in 1958 and ended in 1966. All cuttings since 1966 have been in cutover stands. Timber harvest for poles began in 1961. Harvest for pulp began in 1962, but has since declined.

Ponderosa pine is the principal timber species and makes up about 95 percent of the timber harvested. The less extensive Douglas-fir, white fir, and limber pine are harvested at the higher elevations along the Mogollon Rim.

The best timber-producing soils are the Soldier, Sponseller, and Siesta soils. These soils occur between East Clear Creek and the Mogollon Rim and between West Clear Creek and the Rim. The Hogg and McVickers soils are the next best. Other important timber soils are the Broliar, Chilson, Jacks, Overgaard, Palomino, Sanchez, and Wildcat soils.

Soil texture, elevation, compactness of the subsoil, and soil depth influence the growth of ponderosa pine. The best timber-producing soils in the Area are at the higher elevations where the environment is favorable for trees. They have a thick, friable surface layer and a permeable subsoil that commonly extends to a depth of more than 3 feet.

In table 4, the soils are grouped according to their suitability for timber. Groupings are based on the site-index values for ponderosa pine. Site index is the average height, in feet, of the dominant and codominant trees at 100 years of age. The site-index values were computed from site-index curves for ponderosa pine developed by Meyer (5). Generally, soils that have the higher site-index values produce the higher yields of timber per acre. Site-index values in the Area range from 46 to 90.

The timberland in the Area is under sustained-yield

management. Mature and excess trees are cut, and proper stocking levels are maintained to stimulate growth and to sustain yields. Fire protection is provided through a system of lookouts and fire patrolmen and through practices that reduce the fire hazard. Proper silvicultural practices and methods of direct control provide protection against insects and disease. Pruning, noncommercial thinning, and commercial cutting improve the quality of the timber and increase its growth potential. Reforestation is achieved through planting, seeding, and natural regeneration. Cross ditching, seeding grass, scattering slash, and constructing water bars help to control erosion on skid trails, roads, and landings.

Plant competition.—The encroachment of undesirable species into openings made in the canopy by timber cutting or fire impedes the growth of desirable plant species. Alligator juniper and Gambel oak are the chief competing species in the Long Valley Area. The competition is *slight* if the competing plants do not prevent natural regeneration or early growth of desirable species, or do not interfere with the growth of planted seedlings. The competition is *moderate* if the competing plants delay natural or artificial regeneration, but do not prevent the growth of a fully stocked, normal stand. The competition is *severe* if, in the absence of intensive preparation and maintenance, the competing plants prevent adequate, natural restocking or natural regeneration of desirable species.

Equipment limitation.—Forest management can be hampered by soil characteristics and topographic features that restrict or prevent the use of equipment. The main factors affecting the use of equipment are slope, stoniness, erosion hazard, and wetness. A rating of *slight* indicates no special limitation in the use of equipment. A rating of *moderate* indicates that not all types of equipment can be used or that unfavorable soil characteristics limit the times that the equipment can be used. For example, during short periods after the frost leaves the soil in spring and occasionally after summer rainfall, the forested soils in the Area are too wet and soft to support equipment. A rating of *severe* indicates serious limitations to the use of conventional equipment. Excessively steep slopes and a large number of rock outcrops are examples of severe limitations.

Erosion hazard.—The erosion hazard is rated according to inherent soil characteristics and factors, such as slope, aspect, and surface stoniness. Ratings of *slight*, *moderate*, and *high* are used to indicate the susceptibility of a soil to erosion if the soil is disturbed or if it lacks vegetative cover. A rating of *slight* indicates that only a small loss of soil occurs where the soil is disturbed or the vegetative cover is depleted. A *moderate* rating indicates that significant loss of soil occurs where the soil is disturbed or the cover is depleted. Roads, skid trails, and landings must be carefully planned and constructed to prevent loss of soil. A *high* rating indicates a substantial loss of soil. Harvesting must be done carefully, and special logging methods that minimize soil disturbance are advisable. All roads and skid trails should be adequately drained and carefully located and constructed to control excessive runoff and avoid erosion. After logging has been completed, all roads, skid trails, and landings must be seeded.

TABLE 4.—*Timber groups*

Timber group and map symbols	Site index ¹ for ponderosa pine	Reforestation limitations	Plant competition	Equipment limitation	Erosion hazard	Acres	Percent of timberland
Group 1: ScB, SiC, SiE, SnE.	75 or more----	Slight-----	Slight-----	Slight-----	Slight to high.	64, 892	24
Group 2a: BiB, HiC, McC, MhC, MhD, OvD, SeD, SmF.	74 to 55-----	Moderate-----	Moderate-----	Moderate-----	Slight to moderate.	55, 367	21
Group 2b: BrC, ChE, HgD, PaC, WcB.	74 to 55-----	Severe-----	Moderate-----	Moderate to severe.	Slight to moderate.	94, 694	35
Group 3: BrD, JaD, JtD, JtE, SaC, WdD.	54 or less-----	Severe-----	Moderate to severe.	Severe-----	Moderate to high.	52, 072	20

¹ The average height, in feet, of the dominant and co-dominant trees at 100 years of age. The site-index values for the groups correspond with those used in the Southwestern Region of the Forest Service to denote high, medium, and low site-quality classes.

Timber groups

Nearly all the timberland in the Long Valley Area is under Forest Service administration. The timbered soils have been grouped according to their estimated potential for productivity, based on site index, reforestation limitations, plant competition, equipment limitations, and erosion hazard. The groups are numbered in decreasing order of productivity. The ratings, acreage, and proportionate extent of each of the timber groups are shown in table 4.

TIMBER GROUP 1

Timber group 1 designates soils of a high site-quality class. The soils are more than 3 feet deep over bedrock. In this group are the Siesta (ScB), Soldier (SiC, SiE), and Sponseller (SnE) soils.

The surface layer is loam or silt loam. The subsoil is clay and clay loam. There are cobblestones, stones, or pebbles on the surface of the soil and in the profile.

Natural reforestation limitations are slight. Cobblestones on the surface of the Soldier soils may hinder planting of seedlings. Plant competition is slight. During certain periods, wetness causes a slight equipment limitation. The erosion hazard is slight on the less sloping soils and is high on the steeper Sponseller and Soldier soils.

TIMBER GROUP 2a

Timber group 2a designates soils of a medium site-quality class. The soils are more than 2 feet deep over bedrock. The McVickers soil (McC) is the best timber-producing soil in the group. It is mapped with Hogg (MhC, MhD) and Soldier (SmF) soils. Also in this group are Overgaard (OvD), Hogg (HiC), Broliar (BB), and Siesta (ScD) soils.

The surface layer of these soils is very fine sandy loam, fine sandy loam, sandy loam, loam, or clay loam. The subsoil is clay. In most areas there are cobblestones, stones, or gravel on the surface of the soil and in the profile.

Natural reforestation limitations are moderate. Plantation plantings of seedlings are restricted on soils that have an appreciable number of stones or rock outcrops. Plant competition from Gambel oak and alligator juniper is moderate. Mistletoe infestation is moderate on the Broliar and Overgaard soils. Steep slopes, the clay sub-

soil near the surface, and rock outcrops cause a moderate equipment limitation. The erosion hazard is low to moderate.

TIMBER GROUP 2b

Timber group 2b designates soils of a medium-to-low site-quality class. Most of the soils are more than 2 feet deep over bedrock. The largest acreage is the Broliar soil (BrC). Also in this group are Chilson (ChE), Hogg (HgD), Palomino (PoC), and Wildcat (WcB) soils.

The surface layer is gravelly, cobbly, and stony clay loam and fine sandy loam. The subsoil is clay in all but the Palomino soil, which has a sandy clay loam subsoil.

Reforestation limitations are severe. Mistletoe infestation is a problem in the dense stands of saplings. Plant competition from Gambel oak is moderate after timber harvest. Steep slopes and wetness cause a moderate-to-severe equipment limitation. The erosion hazard is low to moderate.

TIMBER GROUP 3

Timber group 3 designates soils of a low site-quality class. Depth to bedrock ranges from 6 inches to 4 feet. In this group are the Jacks-Tortugas (JtD, JtE), Jacks (JcD), Sanchez (ScC), Broliar (BrD), and Wildcat (WdD) soils.

The surface layer is sandy loam, fine sandy loam, and clay loam. The subsoil is sandy clay loam and clay. All of these soils have many large stones on the surface and throughout the profile.

Range Management

The kind and amount of range herbage produced depend on the elevation, the climate, the relief, and the characteristics of the soil. Three major types of vegetation are represented in the Long Valley Area: ponderosa pine, pinyon-juniper, and grassland-desert shrub. Of these, the ponderosa pine forest type is the most extensive. The areas occupied by these three types differ in elevation, climate, relief, and soils.

The most suitable soils for the production of herbage are the soils on bottom land and the soils on uplands that are deep over bedrock and have a high available water capacity. Soils that are shallow over bedrock are likely to be droughty and, consequently, poor for production of herbage.

The soils in the Area have been grouped according to their estimated productivity of range herbage. Each range herbage group is described in terms of general soil characteristics such as slope, depth, texture, permeability, and stoniness. Then, based on the estimated herbage production and the revegetation potential, the soils have been grouped according to their potential for range improvement. Each range improvement group is also described in terms of general soil characteristics.

Range herbage groups

The range herbage estimates, which apply only to the soils in the survey area, are based on limited studies of herbage clippings. Brief descriptions of the five range herbage groups and yields in pounds of herbage per acre are given in table 5.

RANGE HERBAGE GROUP 1

Soils in group 1 have the highest potential for range herbage production. They are the soils of the Luth-Clover Springs soil management area. They make up less than 1 percent of the survey area, but provide most of the total yield of herbage for livestock and wildlife.

RANGE HERBAGE GROUP 2

Soils in group 2 make up about 40 percent of the survey area. They are mainly in the Siesta-Sponseller, Spring-

erville-Gem, Soldier-McVickers, and Glendale-Anthony management areas. Soils of the Springerville-Gem area, in the pinyon-juniper woodland type, produce most of the herbage in group 2. Not all of the acreage in the Glendale-Anthony area, which is in grassland-desert shrub vegetation, is used for herbage production. Part of it is cultivated. Soils of the Siesta-Sponseller and Soldier-McVickers management areas have a fairly high potential for herbage production. They are in ponderosa pine vegetation, however, and yields are somewhat lower as a result of the dense pine canopy.

RANGE HERBAGE GROUP 3

Group 3 consists mainly of soils of the Broliar and Hogg-Jacks-Wildcat soil management areas and the Winona soils of the Tortugas-Winona-Retriever area. All but Winona soils are in the ponderosa pine forest. The total herbage yield is somewhat higher for group 3 than for group 2.

RANGE HERBAGE GROUP 4

Soils in group 4 do not produce large amounts of herbage. They are mostly soils of the Tortugas-Winona-Retriever management area, in the pinyon-juniper woodland, and of the Graham-House Mountain area in grassland-desert shrub vegetation.

TABLE 5.—Range herbage groups

Groups and soils	Extent		Estimated production on range in—	
	Acres	Percent of survey area	Good condition	Fair to poor condition
Group 1: Nearly level to very gently sloping soils that formed in alluvium in open parks and drainageways. The surface layer is silt loam, loam, and clay loam. The subsoil is loam and clay loam. Infiltration is good, but the water table is seasonally high. Permeability is moderate or slow. The capacity to supply moisture to plants is high. The effective rooting depth is more than 40 inches. C1B, FrA, LuB.	5, 282	0. 8	<i>Lb./acre air dry</i> 1,500 or more-----	<i>Lb./acre air dry</i> 700.
Group 2: Nearly level to steep soils. The surface layer ranges from very fine sandy loam to clay. The subsoil ranges from very fine sandy loam to clay. Infiltration is good on most of the soils. Permeability ranges from moderately rapid to very slow. The capacity to supply moisture to plants is moderately high. AnA, B1B, GcD, GdC, GeB, GuB, HgD, H1C, LyB, McC, MhC, MhD, NaB, ScB, SeD, SIC, S1E, SmF, SnE, SpC, SrC, SsD.	254, 577	41. 1	1,100 to 1,400-----	500 to 600.
Group 3: Nearly level to moderately steep, gravelly, cobbly, and stony soils. The surface layer ranges from fine sandy loam to clay loam. The subsoil ranges from loam to clay. Most of the soils take in water well. Permeability is moderate to very slow. The capacity to supply moisture to plants is moderate. The effective rooting depth is more than 12 inches. BrC, BrD, CaF, Cbd, CeD, ChE, CoB, D1C, DvD, HaB, JaD, OvD, PeC, RtC, WaD, WcB, WnC.	167, 023	26. 7	750 to 1,000-----	250 to 450.
Group 4: Nearly level to steep, cobbly, stony, and rocky soils. The surface layer ranges from loam to clay loam. The subsoil ranges from loam to clay. Permeability is moderate to slow. The capacity to supply moisture to plants is low. The effective rooting depth is more than 6 inches. BcD, BeD, Cr, DeE, GhD, GhF, HmD, JtD, JtE, PaC, ReC, RsD, SaC, ToD, WdD.	90, 662	14. 2	300 to 700 -----	100 to 200.
Group 5: Extensive areas of rock outcrop, rock land, and stony land, and a few areas of shallow soils. Steep and very steep slopes, cliffs, and escarpments. Ba, St.	109, 079	17. 2	100 to 250-----	Less than 100.

RANGE HERBAGE GROUP 5

Group 5 consists of land types that are poorly suited to range herbage production. Plants grow only in pockets where water accumulates and some soil has formed. Most of the land types are steep to very steep, and the ledges and escarpments are barriers to the movement of livestock.

Management practices

Improved production of range herbage can be obtained by—

1. Excluding all livestock from an area of range during the growing season.
2. Eradicating or controlling brush and nonforage plants to increase the supply of moisture available for range plants.
3. Revegetating the range with native or improved grasses and shrubs to increase the yield of herbage, control erosion, and conserve moisture.
4. Building stock tanks or trick tanks, developing springs and wells, and properly locating these watering places to keep the stock distributed over the range.
5. Salting to attract stock to areas that have no water.
6. Fencing to divide the range into effective management units.

Range improvement groups

Range improvement groups are shown in table 6. Each group is described in terms of general soil characteristics. Also shown in table 6 are the mapping units in each group, the total acreage, and the proportionate extent of the acreage within the survey area.

RANGE IMPROVEMENT GROUP 1

Range improvement group 1 consists of soils that are mostly under pine canopy and have similar characteristics. Strong competition from pine trees reduces the amount of available moisture and plant nutrients. Revegetation of native or improved range plants is feasible on only a few soils in this group. The small, narrow areas of Clover Springs, Friana, and Luth soils have the highest revegetation potential of soils in the ponderosa pine forest, and the Gem soils have the highest potential in the pinyon-juniper woodland. All of the soils in group 1 are suitable for construction of stock tanks.

RANGE IMPROVEMENT GROUP 2

Range improvement group 2 is dominantly Springer-ville soils. These soils are well suited to plant-control projects, such as juniper removal, but they are difficult to revegetate because the clay surface layer cracks when dry. The Winona soils in this group are suited to plant-control projects and for seeding to adapted grasses. Brol-liar, Jacks, McVickers, Hogg, Siesta, and Wildcat soils have a timber canopy. The alluvial soils, for example, the Anthony, Glendale, Guest, Hantz, and Navajo soils, have a moderate revegetation potential. All but the Winona soils are suitable for construction of stock tanks.

TABLE 6.—Range improvement groups

Range groups and mapping units	Acres	Percent of survey area
Group 1: Nearly level to strongly sloping soils that are mostly more than 3 feet deep over bedrock. The surface layer ranges from very fine sandy loam to clay loam, and the subsoil ranges from loam to clay. Soils under grass: ClB, FrA, GcD, LuB. Soils under timber: HgD, HlC, McC, MhC, OvD, ScB, SlC.	114, 317	18. 4
Group 2: Nearly level to moderately steep soils that are mostly more than 3 feet deep over bedrock. The surface layer ranges from very fine sandy loam to clay. The subsoil is mostly sandy clay loam, clay loam, and clay. Soils under grass: AnA, CoB, DfC, GdC, GeB, GuB, HaB, NaB, PeC, RlC, SpC, SrC, SsD, WaD, WnC. Soils under timber: BlB, JaD, MhD, SeD, WcB.	149, 450	23. 9
Group 3: Dominantly strongly sloping to steep, cobbly, stony, and rocky soils that are mostly 1 to 2 feet deep over bedrock. Some are deeper. Soils under grass: Ba, BdC, BeD, CaF, CbD, CeD, Cr, DeE, DvD, GhD, GhF, HmD, Ls, LyB, ReC, RsD, St, ToD. Soils under timber: BrC, BrD, ChE, JtD, JtE, PaC, SaC, SlE, SmF, SnE, WdD.	362, 856	57. 7

RANGE IMPROVEMENT GROUP 3

Range improvement group 3, which is about 58 percent of the survey area, consists of soils that have a low revegetation potential. They are typically soils that are shallow over bedrock. Some are steep, some have a high content of coarse fragments, and some are highly susceptible to erosion. Steep slopes and coarse fragments are limitations to the use of mechanical seeding equipment.

Lynx soils have a high potential for herbage production, but a low rating for revegetation. The top inch of the surface layer puddles and then forms a crust that impedes the emergence of seedlings. The Brol-liar, Chilson, Jacks, Palomino, Soldier, McVickers, Sponseller, and Wildcat soils in group 3 are under ponderosa pine vegetation.

Watershed Management

Water is an important product of the Long Valley Area. West Clear Creek, a perennial stream, contributes significantly to the annual flow of the Verde River. Fossil Creek also drains into the Verde River, but most of its flow is impounded for use by a power plant. East Clear Creek and a tributary, Barbershop Canyon, are perennial streams that empty into the Little Colorado River. Most of the water from the Area comes as runoff of snowmelt in spring. Except for flash floods, summer precipitation adds little volume to the total annual runoff. There are a number of springs in the deeply cut

channels of Fossil Creek, East Clear Creek, and West Clear Creek.

In the Long Valley Area, surface runoff is the chief source of water. The capacity of the soils to supply water to streams and drainageways varies. Soils in areas that have more precipitation normally yield more water than soils in areas that have less precipitation. Typically, the soils under ponderosa pines yield water for a period of several months, but the soils under pinyon-juniper and grassland-desert shrub vegetation yield water for a period of only several days.

The effectiveness of a watershed is influenced by geology, relief, vegetation, climate, and soils. Table 7 shows the infiltration rate, permeability rate, and water-storage capacity of each of the soils in the survey area. A knowledge of the hydrologic properties of soils is essential in judging the probable value and condition of a watershed and in making hydrologic analyses. The water-storage values shown in table 7 are a function of soil texture, soil porosity, and the depth of the soil over a substance that restricts air, water, and roots. Soils that are 4 to 5 feet deep over bedrock, such as the Friana and Lynx soils, have 18 to 20 inches of water-storage capacity. Soils that are $\frac{1}{2}$ to $1\frac{1}{2}$ feet deep over bedrock, such as the Sanchez and Winona soils, have 3 to 5 inches of water-storage capacity. These estimated storage values are based on climatic data and on general knowledge about soil behavior.

Hydrologic soil groups

Criteria established by hydrologists of the Soil Conservation Service, the Forest Service, and other agencies are used to group soils according to their runoff potential. Groupings are based on soil properties that influence runoff, such as infiltration rate, texture, natural drainage or wetness, and the presence of a restrictive underlying layer or rock material. The runoff potential is calculated on the basis of water intake at the end of a long-duration storm that occurs after prior wetting and opportunity for swelling of a soil not protected by vegetation. The slope is not considered.

The four hydrologic groups are described as follows:

Group A. Soils have a rapid infiltration rate, even when thoroughly wetted; chiefly deep, well-drained to excessively drained sand, gravel, or both; high water transmission rate; low runoff potential.

Group B. Soils have a moderate infiltration rate when thoroughly wetted; chiefly moderately deep to deep, moderately well drained to well drained, and moderately fine textured to moderately coarse textured; moderate water transmission rate; moderately low runoff potential.

Group C. Soils have a slow infiltration rate when thoroughly wetted; chiefly moderately fine textured to fine textured soils that have a layer impeding movement of water; slow water transmission rate; moderately high runoff potential.

Group D. Soils have a very slow infiltration rate when thoroughly wetted; chiefly clays that have a high swell potential, soils that have a high permanent

water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material; very slow water transmission rate; high runoff potential.

The Southwestern Region of the Forest Service has augmented the hydrologic soil group classification by including a numerical depth notation (4). The numeral 1 designates soils that are no more than 20 inches deep over bedrock. The numeral 2 designates soils that are deeper than 20 inches. The numeral 3 designates miscellaneous land types. For example, a "C1" soil is in hydrologic group C and is more than 20 inches deep over bedrock; a "C2" soil is in hydrologic group C and is more than 20 inches deep. "D3" is a miscellaneous land type that is in hydrologic group D.

In using a hydrologic grouping to estimate the runoff potential of a soil, it is necessary to take into account precipitation, slope, effect of vegetative cover, and other factors. If an estimate of runoff is needed for use in planning the management of a particular watershed or area, a hydrologist should be consulted.

Erodibility and erosion hazard

The erodibility of a soil, or its susceptibility to removal of surface soil by water, must be considered in planning land use. Table 7 shows the degree of erodibility and an estimate of the erosion hazard for each soil in the survey area.

The erodibility ratings in table 7 do not take into account such factors as climate, vegetation, slope, and volume and velocity of runoff. They are based on—

1. The stability and size of the soil aggregates.
2. The ease with which the aggregates can be detached and transported by moving water.
3. The permeability of the soil.
4. The presence of rock or other restricting material near the surface.
5. The water-storage capacity of the soil.
6. The percentage of the surface area that is protected by coarse fragments.

Highly erodible soils in the Long Valley Area are those in which the surface aggregates are not stable because the particles have been dispersed or because the organic-matter content is low. The surface layer of the Hantz, Springerville, and Retriever soils is extremely unstable when wet, and the individual soil grains can be easily detached. The surface layer of Retriever very stony loam, however, is less erodible than that of other Retriever soils because it is covered with coarse fragments. The shale parent material is the cause of the instability of the Hantz soils. The churning nature of the Springerville soils is the cause of their unstable surface.

The erosion hazard depends partly on erodibility and partly on climate, slope, and other environmental factors. This hazard expresses the susceptibility of a soil to accelerated erosion if the vegetation is disturbed or destroyed by fire, clearcutting of timber, overgrazing, trampling by livestock, or other causes. The estimates in table 7 are based on conditions in the Area and take into account the amount and intensity of rainfall on each soil.

TABLE 7.—*Hydrologic factors, erodibility classification, and erosion hazard*

Soil	Infiltration ¹	Permeability ¹	Water-storage capacity	Hydro-logic soil subgroup	Erodibility	Erosion hazard
Anthony fine sandy loam, 0 to 2 percent slopes----	Moderately rapid.	Moderately rapid.	<i>In</i> 20-22	B2	High-----	Moderate.
Basalt rock land-----	(²)	(²)	(²)	D3	Moderate---	High.
Bridge gravelly sandy loam, 0 to 15 percent slopes----	Moderate-----	Moderate-----	5-7	C2	Moderate---	Moderate.
Bridge cobbly loam, 10 to 30 percent slopes-----	Moderate-----	Moderate-----	5-7	B2	Moderate---	Moderate.
Broliar clay loam, 0 to 5 percent slopes-----	Slow-----	Slow-----	8-10	C2-D2	Moderate---	Slight.
Broliar very stony clay loam, 0 to 10 percent slopes.	Slow-----	Slow-----	8-10	C2-D2	Moderate---	Moderate to slight.
Broliar very stony clay loam, 10 to 30 percent slopes.	Slow-----	Slow-----	8-10	C2-D2	Moderate---	High.
Cabazon cobbly clay loam, 20 to 60 percent slopes--	Slow-----	Slow-----	6-8	D1	Moderate---	Moderate to high.
Cabazon very stony clay loam, 0 to 20 percent slopes.	Slow-----	Slow-----	6-8	D1	Low-----	Moderate to slight.
Cabazon extremely rocky loam, 0 to 20 percent slopes.	Moderate-----	Slow-----	6-8	D1	Moderate---	Slight.
Chilson cobbly clay loam, 20 to 45 percent slopes---	Slow-----	Slow-----	5-7	D1	Moderate---	Moderate to high.
Clover Springs silt loam, 0 to 5 percent slopes-----	Moderate-----	Moderate-----	18-20	B2	High-----	Moderate to high.
Cornville fine sandy loam, 0 to 5 percent slopes----	Rapid-----	Moderately slow.	12-14	B2	High-----	Moderate.
Cowan and Arizo soils-----	Rapid-----	Rapid and very rapid.	8-10	A2	Low-----	High.
Disterheff very stony clay loam, 20 to 45 percent slopes.	Slow-----	Slow to moderate.	14-17	C2	Moderate---	Moderate to high.
Dye fine sandy loam, 0 to 10 percent slopes-----	Moderate-----	Slow-----	5-7	D1	High-----	Moderate.
Dye very stony fine sandy loam, 0 to 20 percent slopes.	Moderate-----	Slow-----	5-7	D1	High-----	Moderate to high.
Friana clay loam, 0 to 2 percent slopes-----	Moderate-----	Slow-----	18-20	D2	Moderate---	Slight.
Gem cobbly clay loam, 0 to 20 percent slopes-----	Moderate-----	Slow-----	8-10	D2	Moderate---	Moderate.
Glendale gravelly fine sandy loam, 0 to 10 percent slopes.	Moderate-----	Moderately slow.	21-24	B2	Moderate---	High.
Glendale gravelly silt loam, 0 to 5 percent slopes---	Moderate-----	Moderately slow.	21-24	B2	Moderate---	High.
Graham and House Mountain soils, 0 to 30 percent slopes.	Moderate-----	Slow and moderate.	2-5	D1	Moderate---	Moderate.
Graham and House Mountain soils, 30 to 60 percent slopes.	Moderate-----	Slow and moderate.	2-5	D1	Moderate---	High.
Guest clay, 0 to 5 percent slopes-----	Slow-----	Slow-----	22-25	D2	Moderate---	Moderate to high.
Hantz gravelly silty clay, 0 to 5 percent slopes-----	Slow-----	Very slow-----	22-25	D2	High-----	High.
Hogg fine sandy loam, 0 to 20 percent slopes-----	Moderate-----	Slow-----	15-18	C2	Moderate---	High.
Hogg loam, calcareous variant, 0 to 10 percent slopes.	Moderate-----	Slow-----	15-18	C2	Moderate---	Moderate.
House Mountain stony loam, 0 to 30 percent slopes.	Moderate-----	Moderate-----	2-4	D1	Moderate---	Moderate.
Jacks fine sandy loam, 0 to 20 percent slopes-----	Moderate-----	Slow-----	12-14	C2	Moderate---	Moderate.
Jacks-Tortugas extremely rocky complex, 0 to 20 percent slopes.	Moderate-----	Slow and moderate.	3-8	C2, D1	Moderate---	Moderate.
Jacks-Tortugas extremely rocky complex, 20 to 45 percent slopes.	Moderate-----	Slow and moderate.	3-8	C2, D1	Moderate---	High.
Limestone and sandstone rock land-----	(²)	(²)	(²)	(²)	(²)-----	(²).
Luth clay loam, 0 to 5 percent slopes-----	Moderate-----	Slow-----	22-24	C2	High-----	High.
Lynx fine sandy loam, 0 to 5 percent slopes-----	Moderately rapid.	Moderately slow.	18-20	B2	Moderate---	High.
McVickers very fine sandy loam, 0 to 10 percent slopes.	Moderately rapid.	Slow and very slow.	12-14	C2	Moderate---	Slight to moderate.
McVickers-Hogg complex, 0 to 10 percent slopes---	Moderately rapid.	Slow and very slow.	12-16	C2	Moderate---	Moderate.
McVickers-Hogg complex, 10 to 30 percent slopes--	Moderately rapid.	Slow-----	12-16	C2	Moderate---	Moderate to high.
Navajo silty clay, 0 to 5 percent slopes-----	Slow-----	Very slow-----	20-24	D2	Moderate---	Moderate.
Overgaard sandy loam, 0 to 20 percent slopes-----	Moderately rapid.	Slow-----	14-17	C2	Moderate---	Moderate.
Palomino very stony fine sandy loam, 0 to 15 percent slopes.	Moderate-----	Moderately slow.	3-5	D1	High-----	Slight.
Penthouse cobbly loam, 0 to 10 percent slopes-----	Moderate-----	Very slow-----	16-19	D2	High-----	Moderate.
Retriever loam, 0 to 10 percent slopes-----	Moderate-----	Moderate-----	2-4	D1	High-----	Moderate.

See footnotes at end of table.

TABLE 7—*Hydrologic factors, erodibility classification, and erosion hazard*—Continued

Soil	Infiltration ¹	Permeability ¹	Water-storage capacity	Hydro-logic soil subgroup	Erodibility	Erosion hazard
Retriever very stony loam, 0 to 30 percent slopes..	Moderate.....	Moderate.....	<i>m</i> 2-4	D1	High.....	Moderate to high.
Rimrock cobbly clay, 0 to 10 percent slopes.....	Slow.....	Slow.....	13-15	D2	High.....	Moderate.
Sanchez extremely stony sandy loam, 0 to 15 percent slopes.	Moderately rapid.	Moderate.....	3-5	D1	High.....	Moderate.
Siesta loam, 0 to 5 percent slopes.....	Moderate.....	Slow.....	18-20	D2	Moderate...	Slight.
Siesta cobbly loam, 0 to 20 percent slopes.....	Moderate.....	Slow.....	12-15	D2	Moderate...	Moderate.
Soldier cobbly loam, 0 to 10 percent slopes.....	Moderate.....	Very slow.....	18-22	C2	Moderate...	Slight.
Soldier cobbly loam, 20 to 45 percent slopes.....	Moderate.....	Very slow.....	18-22	C2	Moderate...	High.
Soldier-McVickers very rocky complex, 20 to 60 percent slopes.	Moderate.....	Very slow and slow.	14-20	C2	Moderate...	High.
Sponseller gravelly silt loam, 10 to 40 percent slopes.	Moderate.....	Moderately slow.	16-18	B2	Moderate...	Moderate.
Springerville clay, 0 to 10 percent slopes.....	Slow.....	Very slow.....	18-22	D2	High.....	Slight.
Springerville cobbly clay, 0 to 10 percent slopes.....	Slow.....	Very slow.....	18-22	D2	High.....	Moderate.
Springerville-Gem complex, 0 to 20 percent slopes.	Slow.....	Very slow and slow.	10-20	D2	High.....	Moderate.
Stony rough land, ash and tuff.....	Moderate.....	Moderate.....	(2)	D3	(2).....	High.
Tortugas very stony loam, 0 to 30 percent slopes...	Moderate.....	Moderate.....	2-4	D1	Low.....	Moderate.
Waldroup gravelly silty clay loam, 5 to 30 percent slopes.	Moderately slow.	Slow.....	12-15	D2	Moderate...	Moderate to high.
Wildcat gravelly fine sandy loam, 0 to 5 percent slopes.	Moderately rapid.	Very slow.....	12-14	D2	High.....	Moderate.
Wildcat very rocky loam, 0 to 20 percent slopes.....	Moderate.....	Very slow.....	12-14	D2	Moderate...	Moderate.
Winona gravelly loam, 0 to 10 percent slopes.....	Moderate.....	Moderate.....	3-5	D1	Moderate...	Slight.

¹ Very rapid—more than 20 inches per hour.

Rapid—6.3 to 20.0 inches per hour.

Moderately rapid—2.0 to 6.3 inches per hour.

Moderate—0.63 to 2.0 inches per hour.

Moderately slow—0.2 to 0.63 inches per hour.

Slow—0.06 to 0.2 inch per hour.

Very slow—less than 0.06 inch per hour.

² Miscellaneous land type having so little soil material that estimates are not significant.

Wildlife Management

In the paragraphs that follow, each of the areas described in the section "Soil Management Areas" and shown on the general soil map is considered in terms of management that provides and improves habitat for wildlife. The management considered deals mainly with game, such as elk, deer, antelope, turkey, javelina, quail, and dove.

1. *Siesta-Sponseller wildlife management area.*—The Siesta-Sponseller area provides spring, summer, and fall range for deer, elk, and turkey. Habitat can be improved by increasing the supply of palatable forage. Openings in the timber canopy can be seeded to browse, such as elderberry, serviceberry, bitterbrush, and mountain-mahogany, and to grass mixtures, including smooth brome, wheatgrass, and orchardgrass. Thinning of aspen groves to induce sprouting on the Sponseller soils provides additional food for elk and deer. The Siesta soils are suitable sites for construction of wildlife watering ponds.

2. *Brolliar wildlife management area.*—The Brolliar soils have good browse production potential, but available browse is currently lacking. Deer, elk, and turkey use this area in spring, summer, and fall. Canopy openings in the pine, after timber harvest, can be seeded to browse and forage plants, such as orchardgrass, wheatgrass, hard fescue, mountain-mahogany, sweet clover, elderberry, bitterbrush, and serviceberry. Gambel oak provides mast for deer, turkey, and bear. The less stony

and rocky Brolliar soils are suitable sites for wildlife pond construction.

3. *Luth-Clover Springs wildlife management area.*—This soil area consists of open parks and meadows within the ponderosa pine forest. The edge effect of these natural openings is an important element in prime wildlife habitat. The grass and forb herbage provides a major food source for elk and deer. A seeding mixture used to improve the food supply can include burnet, clover, alfalfa, orchardgrass, wheatgrass, and smooth brome.

4. *Springerville-Gem wildlife management area.*—This soil area is winter range for turkey and elk and is year-round range for resident deer herds. Antelope herds occupy the more open parts of the area. Pinyon pine, juniper, and blue grama make up the dominant native vegetation. Suitable species for seeding are cliffrose, mountain-mahogany, buckwheat, fourwing saltbush, coffeeberry, and winterfat. Early spring feed can be supplied by seeding to western wheatgrass, pubescent wheatgrass, tobosa, weeping lovegrass, and Boer lovegrass. Forbs, such as alfalfa, clover, burnet, and sunflower, should be included in the seeding mixture. Both the Springerville and Gem soils are suitable sites for construction of wildlife watering ponds.

5. *Soldier-McVickers wildlife management area.*—These soils produce the best ponderosa pine in the Area. Because the natural regeneration of pine is vigorous, establishing and maintaining adequate levels of sustenance for wildlife is difficult. Temporary food supplies

can be gained by seeding grasses on skid trails and landings after timber harvest. Increasing aspen sprouting by thinning aspen stands at the heads of drains is desirable.

6. *Hogg-Jacks-Wildcat wildlife management area.*—The open forest cover in this soil area is an important element in wildlife habitat. Intensive management of the abundant Gambel oak improves the food supply. The area is used intensively by deer and elk late in fall and early in spring because snow is not so deep as at the higher elevations. Seeding mixtures can include antelope brush, mountain-mahogany, serviceberry, snowberry, clover, Russian wildrye, hard fescue, and big bluegrass. Most of the soils are suitable sites for the construction of wildlife watering ponds.

7. *Tortugas-Winona-Retriever wildlife management area.*—The Tortugas and Winona soils are in the northeastern part of the Area. They are prime winter range for wildlife. Cliffrose is the chief browse plant. Wildlife food supply can be increased by removing the juniper and seeding to cliffrose, mountain-mahogany, burnet, black medic, weeping lovegrass, and winterfat.

The Retriever soils in the southwestern part of the Area are in the semidesert grassland zone. Palatable forage for wildlife is difficult to establish on these shallow, stony, and droughty soils. Any introduced forage species considered must be tolerant of the moderately alkaline and strongly calcareous conditions.

The Tortugas, Winona, and Retriever soils are less than 20 inches deep over limestone bedrock and are not suitable for wildlife watering ponds. They are suitable for the construction of trick tanks.

8. *Graham-House Mountain wildlife management area.*—Big game browse is in fair supply on these soils. Plants presently growing are Gambel oak, mesquite, menodora, wolfberry, desert ceanothus, and cliffrose. Establishing additional food supplies is difficult except by hand planting. Present levels of browse and grass production can be maintained under careful management. Shallowness over bedrock makes these soils unsuitable for the construction of wildlife ponds. Trick tanks can be constructed to provide water for wildlife.

9. *Glendale-Anthony wildlife management area.*—Most of the alluvial soils in this area are cultivated. Parts of the area not under cultivation can be seeded to sand dropseed, side-oats grama, winterfat, black grama, sunflower, bee plant, and fourwing saltbush to improve the food supply for dove and quail. In most places the water supply is sufficient for wildlife.

10. *Stony rough land-Basalt rock land wildlife management area.*—Only a small part of this area is soil material. Most of the area is rockland or rock outcrop intermingled with steep, stony canyon sides. This area is important as a place for escape and concealment for wildlife, but little can be done to improve it for use as wildlife habitat. Game herds should be managed to avoid overpopulation and to insure adequate levels of wildlife food.

Recreation Sites

The Long Valley Area offers opportunities for hunting, fishing, camping, and picnicking. Public use of the

Area is increasing, and suitable recreation sites are needed. The soils in the Area have been grouped according to their suitability for recreational activities. In the following paragraphs, each group is described in terms of the characteristics that affect the suitability for recreation.

Recreation groups

The recreation groups in the Area are shown in table 8. The grouping is based on characteristics significant in the design and development of recreation facilities. The main characteristics considered are productivity, stability, depth to bedrock, permeability, stoniness, texture, and slope. Subgroups indicate differences in slope, stoniness, texture, and flood hazard within the group.

The groupings are intended as a guide in determining the suitability of kinds of soil and terrain for recreational activities. Unless otherwise noted, the soil texture mentioned in the descriptions of the recreation groups is the weighted average texture between depths of 10 and 40 inches, or between the surface and bedrock if the soil is shallower than 20 inches.

Erosion hazard, trafficability, compactibility, and suitability for sanitation facilities are among the factors to be considered in determining suitable recreation sites. Ratings for all, by soil groups, are shown in table 8. Column headings in table 8 are defined in the following paragraphs.

The *erosion hazard* is rated according to inherent soil characteristics and observable characteristics, such as slope, aspect, and the number of stones and cobblestones on the surface. A rating of *slight* indicates that only a small amount of soil is lost in disturbed areas or in areas where the plant cover is depleted. A *moderate* rating indicates that disturbance of the surface layer and loss of protective vegetation result in conditions conducive to erosion and that careful planning is needed in constructing picnic sites, campgrounds, and trails. A rating of *severe* indicates that the soils are susceptible to serious erosion and soil loss. It is essential that facilities are carefully located and constructed and that sites are drained to curb excessive runoff and are planted to a protective vegetation.

Trafficability refers to the ability of a soil to support moving vehicles. It is expressed as *good*, *fair*, or *poor*. Soils rated *good* are typically loams or sandy loams, gravelly or nongravelly, that have moderate or strong structure. Loams, sandy loams, and silt loams that have weak structure or are massive are rated *fair*. Soils rated *poor* are clays, clay loams, loose sands, and any stony or rocky soil on which the quantity of stones imposes a serious limitation to trafficability.

Compactibility refers to the ability of a soil to withstand foot traffic. It is expressed as *good*, *fair*, or *poor*. Maintaining a good sod or vegetative cover depends in part on soil texture, fertility, available moisture, and the amount of traffic. Sandy and gravelly soils are rated *good* because they do not compact easily. Fine sandy loams and loams are rated *fair* because they are only slightly compactible. Clays and clay loams are rated *poor* because they compact easily and become slippery and sticky when wet. Extremely sandy or gravelly soils are also rated *poor* because the sod is easily broken.

TABLE 8.—*Recreation groups*

Recreation group and map symbols	Erosion hazard	Trafficability	Compactibility	Suitability for sanitation facilities
Group 1a: McC, MhC, OvD, SiC----	Slight to moderate-----	Good-----	Good-----	Suitable to questionable.
Group 1b: MhD, SiE, SmF, SnE-----	Moderate to high-----	Fair to good-----	Fair to good-----	Questionable.
Group 1c: AnA, ClB, LuB, LyB-----	Moderate to high-----	Fair to good-----	Fair to good-----	Suitable to questionable.
Group 2a: BiB, BrC, CoB, FrA, GcD, HgD, HIC, JaD, PeC, ScB, SeD, WcB.	Slight to moderate-----	Poor to fair-----	Poor to fair-----	Questionable to unsuitable.
Group 2b: BrD, WaD, WdD-----	Moderate to high-----	Poor-----	Poor-----	Unsuitable.
Group 3a: BdC, CbD, DfC, DvD, PaC, ReC, SaC, ToD, WnC.	Slight to moderate-----	Poor to fair-----	Poor to fair-----	Unsuitable.
Group 3b: BeD, CaF, ChE, DeE, GhD, GhF, HmD, JtD, JtE, RsD.	Moderate to high-----	Poor-----	Poor-----	Unsuitable.
Group 4: Cr, GdC, GeB, GuB, HaB, NaB.	High-----	Poor-----	Poor to fair-----	Unsuitable.
Group 5a: CeD, RtC, SpC, SrC, SsD.	Slight to moderate-----	Poor-----	Poor-----	Unsuitable.
Group 5b: Ba, Ls, St-----	Slight to high-----	Poor-----	Poor-----	Unsuitable.

Suitability for sanitation facilities, as used in table 8, refers to the suitability of soils as sites for septic tanks and filter fields. It is expressed as *suitable*, *questionable*, or *not suitable*. Factors considered in determining the ratings include soil permeability, slope gradient, ground water level, flood hazard, and depth to bedrock or other impervious material. Soils are rated as *suitable* if they are 4 feet or more deep over impervious material and permeability is moderately rapid (2.0 to 6.3 inches per hour). Soils are rated *questionable* if they are less than 4 feet deep over impervious material and permeability is moderate (0.63 to 2.0 inches per hour). Soils are rated *not suitable* if they are less than 3 feet deep over bedrock and permeability is low (less than 0.63 inch per hour).

RECREATION GROUP 1

The soils in this group are more than 3 feet deep over bedrock and range from clay to sandy loam. They have good trafficability and compactibility. In most places they can be easily graded and landscaped. They are the best in the Area for planting and sustaining shrubbery and exotic plants. Three subgroups have been established.

The soils in subgroup 1a have few natural limitations and present little difficulty in construction. They are on uplands and have slopes of 0 to 10 percent. They are mostly clays derived from sandstone, limestone, or gravelly old alluvium. McVickers, Overgaard, and Soldier soils are in this subgroup.

The soils in subgroup 1b are similar to those in subgroup 1a, but range from sandy loam to clay and have slopes of 10 to 60 percent. The dominant slopes are 15 to 45 percent. McVickers, Soldier, and Sponseller soils are in this subgroup.

The soils in subgroup 1c are more than 5 feet deep over bedrock and are mostly clay loam. Most are well drained, but are subject to flooding for short periods. Anthony, Clover Springs, Luth, and Lynx soils are in this subgroup. The Clover Springs soils have a seasonal high water table.

RECREATION GROUP 2

This group consists of clay soils that are more than 3 feet deep over bedrock. These soils are poor construc-

tion material. Trafficability and compactibility are fair to poor. Surfacing is essential on all-weather roads and trails. In most places cuts 1 to 2 feet deep expose a heavy, tight, clayey subsoil. In many places the surface area is cobbly or stony. Two subgroups have been established.

Brolliar, Cornville, Friana, Gem, Hogg, Jacks, Penthouse, Siesta, and Wildcat soils are in subgroup 2a. The Friana soils are moderately well drained. The rest are well drained. Slopes are typically less than 5 percent.

Brolliar, Wildcat, and Waldroup soils are in subgroup 2b. The surface area of Brolliar and Wildcat soils is stony and rocky, and that of Waldroup soil is gravelly. Slopes are 10 to 30 percent.

RECREATION GROUP 3

This group consists of mostly stony clays that are about 6 to 48 inches deep over bedrock and have fair to poor trafficability and compactibility. Considerable hard-rock excavation is required in placing waterlines below the freezing zone and in digging pit toilets. Two subgroups have been established.

Bridge, Cabezon, Dye, Palomino, Retriever, Sanchez, Tortugas, and Winona soils are in subgroup 3a. The texture ranges from loam to clay. The depth to bedrock is 6 to 18 inches. The slope range for Tortugas soils is as much as 20 percent. For the rest it is 0 to 10 percent. Winona soils have good trafficability.

Bridge, Cabezon, Chilson, Disterheff, Graham, House Mountain, Jacks, Retriever, and Tortugas soils are in subgroup 3b. All are clays. The depth to bedrock is 1 to 4 feet. Slopes are 10 to 45 percent.

RECREATION GROUP 4

The soils in group 4 formed in alluvium more than 5 feet thick. They are on bottom land and in drainage-ways and are subject to flooding. The texture ranges from sand to clay. Slopes are less than 5 percent. Many areas are severely gullied. Trafficability and compactibility are poor. Arizo, Cowan, Glendale, Guest, Hantz, and Navajo soils are in this group. No subgroups have been established.

RECREATION GROUP 5

Deep clays that have a high shrink-swell potential and three land types are in this group. The clays have poor trafficability and compactibility. They are poorly suited as construction material and are not good for roads. The land types are mostly very steep, shallow, stony, and rocky.

The soils in subgroup 5a have slope gradients of as much as 20 percent. They have slow permeability and are unsuitable as filter fields for septic tank sewage disposal. Cabezon, Gem, Rimrock, and Springerville soils are in this subgroup.

Basalt rock land, Limestone and sandstone rock land, and Stony rough land, ash and tuff, are in subgroup 5b. They are the least suitable in the Area for the development of recreation sites. Slopes range from 40 to 80 percent, and there are some vertical cliffs and escarpments.

Soils and Engineering

The information on the pages that follow can be used in selecting sites for structures, in locating materials suitable for the type of structure planned, and in designing and maintaining engineering structures.

With the use of the soil map for identification of soil areas, the interpretations reported in tables 9, 10, and 11 can be useful for many purposes. It should be emphasized that they do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the depth of layers here reported. Even in these situations, however, the soil map is useful in planning more detailed field investigations and in indicating the kinds of problems that may be expected.

Engineering Properties, Interpretations, and Test Data

Estimates of soil properties significant in engineering are shown in table 9.

Estimates in the column headed "Permeability," which is the ability of the soil to transmit water, is important in the construction of foundations. It is also important in constructing highway embankments and highway subgrades. The estimates are for soils that are not compacted.

Soil reaction is expressed in terms of pH values. A value between pH 6.6 and 7.3 is neutral, a value lower than 6.6 indicates acidity, and a value higher than 7.3 indicates alkalinity.

TABLE 9.—*Estimates of soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in referring to other series that appear in the first column of this

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Anthony: AnA-----	In. >60	In. 0-72	Fine sandy loam and sandy loam-----	SC or SM	A-2
Arizo----- Mapped only with Cowan soils.	>60	0-72	Very gravelly coarse sand and sand-----	GP	A-1
Basalt rock land: Ba. No valid estimates can be made.					
Bridge: BdC, BeD-----	22-40	0-24 24	Cobbly loam, gravelly sandy loam, loam and sandy clay loam. Tuff and ash.	SC, ML, or SM	A-4 or A-6
Brolliar: BlB, BrC, BrD-----	24-60	0-24 24	Very stony clay loam over cobbly clay. Basalt.	CL or CH	A-6 or A-7
Cabezón: CaF, CbD, CeD-----	8-20	0-17 17	Clay; very stony or cobbly surface layer. Basalt.	CH	A-7
Chilson: ChE-----	10-20	0-17 17	Gravelly clay----- Sandstone and shale.	CL	A-6
Clover Springs: ClB-----	>60	0-60	Silt loam and loam-----	ML	A-4
Cornville: CoB-----	>60	0-30 30-60	Sandy clay loam----- Gravelly loam-----	SC SM	A-4 A-4
*Cowan: Cr----- For Arizo part of Cr, see Arizo series. See footnote at end of table.	>60	0-60	Loamy fine sand, fine sandy loam, and loamy sand.	SM	A-2

The estimates for shrink-swell potential indicate the volume change to be expected with change in moisture content. Typically, soils classified as CH or A-7 have a high shrink-swell potential. Most soils having a clayey subsoil tend to slough and slide when wet. On such soils, construction work or transportation of heavy equipment during wet periods is hazardous.

Suitability of the soils of the Area for the engineering practices most commonly needed in management of wild land is shown in table 10. The interpretations in this table are based on the estimates shown in table 9, on the test data shown in table 11, and on field experience. Interpretations for land types are not given because these areas are so variable that useful interpretations cannot be made.

Classification Systems

The two systems most commonly used in classifying soils for engineering purposes are the system approved by the American Association of State Highway Officials (AASHO) and the Unified system, approved by the U.S. Army Corps of Engineers.

The AASHO system (1) is used to classify soils according to those properties that affect use in highway

construction. In this system all soil material is classified into seven groups, designated A-1 through A-7. Soils that have the highest bearing strength and are the best soils for subgrade are classified as A-1. Soils that have the lowest strength when wet, clayey soils, are classified as A-7.

The Unified system (9) is based on identification of soils according to texture and plasticity and on performance as engineering construction material. In this system, soils are placed in 15 groups, each identified by a letter symbol. SC and SM represent sand mixed with fines of clay and silt; CL and ML represent clay and silt that have a low liquid limit; CH represents clay and silt that have a high liquid limit; and GP represents gravel and mixtures of gravel and sand.

Soil scientists use the USDA textural classification (7). In this, the texture of the soil is determined according to the proportion of sand, silt, and clay. Textural modifiers, such as gravelly, stony, shaly, and cobbly, are used as needed.

Estimated classifications of all soils in the Long Valley Area according to all three systems of classification are shown in table 9. The AASHO and Unified classification of selected soils in the Area are shown in table 11.

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such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for table. Symbol > means more than. Symbol < means less than]

Percentage passing sieve— ¹				Permeability	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200			
100	100	60-85	20-35	In./hr. 2.00-6.30	7.9-8.4	Low.
15-55	10-50	5-15	0-5	>20.00	7.9-8.4	Low.
70-85	60-80	50-60	40-60	0.63-2.00	7.9-8.4	Low to moderate.
95-100	95-100	85-95	75-85	0.06-0.20	7.4-7.8	High.
90-100	90-100	90-100	75-85	0.06-0.20	6.6-7.8	High.
70-80	60-70	55-65	50-60	0.06-0.20	7.4-8.4	High.
100	100	85-95	60-90	0.63-2.00	6.6-7.3	Moderate.
100	100	80-90	35-50	0.20-0.63	7.9-8.4	Moderate.
65-75	60-70	50-60	40-50	0.63-2.00	7.9-8.4	Low.
100	100	50-75	15-30	6.3-20.00	7.9-8.4	Low.

TABLE 9.—*Estimates of soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Disterheff: DeE.....	In. 48-72	In. 0-40	Clay and gravelly clay; very stony surface layer.	CH	A-7
		40-72	Very gravelly loam.....	GC	A-2
Dye: DfC, DvD.....	10-20	0-19	Gravelly clay loam and clay; very stony surface layer in places.	CL	A-6
		19	Sandstone.		
Friana: FrA.....	>60	0-28	Clay.....	CH	A-7
		28-54	Very gravelly clay.....	GC	A-2
		54	Cinders.		
Gem: GcD.....	22-40	0-9	Clay loam and cobbly clay loam.....	CL	A-6
		9-25	Cobbly and stony clay.....	CH	A-7
		25	Basalt.		
Glendale: GdC, GeB.....	>60	0-68	Silty clay loam, clay loam; gravel on surface.	CL	A-6
*Graham: GhD, GhF.....	10-20	0-12	Clay; cobbly surface layer.....	CH	A-7
For House Mountain part of GhD and GhF, see House Mountain series.		12	Basalt.		
Guest: GuB.....	>60	0-62	Clay.....	CH	A-7
Hantz: HaB.....	>60	0-66	Clay; gravelly surface.....	CH	A-7
Hogg: HgD.....	24-60	0-52	Gravelly clay.....	CH	A-7
		52	Limestone.		
Hogg calcareous variant: HIC.....	>60	0-42	Clay.....	CH	A-7
		42-64	Clay loam.....	CL	A-6
House Mountain: HmD.....	4-14	0-8	Stony loam and gravelly loam.....	SM or SC	A-4
		8	Basalt.		
*Jacks: JaD, JtD, JtE.....	20-50	0-7	Sandy clay loam.....	SC	A-6
For Tortugas part of JtD and JtE, see Tortugas series.		7-42	Clay; very stony in lower part.....	CH	A-7
		42	Sandstone.		
Limestone and sandstone rock land: Ls. No valid estimates can be made.					
Luth: LuB.....	>60	0-60	Heavy clay loam and clay.....	CH	A-7
Lynx: LyB.....	48-60	0-8	Fine sandy loam.....	SM	A-4
		8-41	Clay loam.....	CL	A-6
		41-60	Fine sandy loam.....	SM	A-4
*McVickers: McC, MhC, MhD.....	30-60	0-16	Very fine sandy loam.....	ML	A-4
For Hogg part of MhC and MhD, see Hogg series.		16-33	Clay.....	CH	A-7
		33-45	Clay mixed with sandstone fragments.....	CL	A-6
		45	Sandstone.		
Navajo: NaB.....	>60	0-72	Clay.....	CL	A-7
Overgaard: OvD.....	>60	0-10	Gravelly sandy loam.....	SM	A-2
		10-38	Gravelly clay.....	SC	A-7
		38-66	Gravelly clay loam.....	SC	A-6

See footnote at end of table.

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Percentage passing sieve— ¹				Permeability	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200			
70-90	65-85	60-80	50-60	<i>In./hr.</i> 0.06-0.20	7.9-8.4	High.
30-50	15-25	15-20	10-15	0.63-2.00	8.5-9.0	Low.
80-90	75-85	70-80	50-60	0.06-0.20	6.6-7.8	Moderate to high.
95-100	95-100	85-100	80-95	0.06-0.20	6.1-7.3	High.
40-50	30-40	25-35	15-25	0.06-0.20	6.6-7.8	Low.
85-95	80-90	60-70	50-60	0.20-0.63	7.4-7.8	Moderate.
65-85	70-80	60-70	50-60	0.06-0.20	7.9-8.4	Moderate.
95-100	90-100	80-90	50-60	0.20-0.63	7.9-8.4	Moderate.
95-100	90-100	85-95	75-85	0.06-0.20	7.4-7.8	High.
100	100	90-100	75-95	0.06-0.20	7.9-8.4	High.
95-100	90-100	80-90	70-80	0.06	7.9-8.4	High.
90-95	80-90	70-80	50-60	0.06-0.20	7.9-8.4	High.
100	95-100	85-95	70-80	<0.06	7.4-8.4	High.
95-100	90-100	80-90	60-70	0.20-0.63	7.9-8.4	Moderate.
65-85	60-80	50-65	35-50	0.63-2.00	7.4-7.8	Low.
95-100	90-95	80-90	35-50	0.20-0.63	7.4-7.8	Moderate.
95-100	90-95	80-90	70-80	0.06-0.20	7.9-8.4	High.
90-100	85-100	80-95	70-80	0.06-0.20	7.4-8.4	High.
90-100	85-100	70-85	40-50	0.63-2.00	7.4-7.8	Low.
95-100	90-100	90-100	70-80	0.20-0.63	7.4-7.8	Moderate.
95-100	90-100	70-85	40-50	0.63-2.00	7.9-8.4	Low.
95-100	90-95	80-90	50-65	0.63-2.00	6.1-6.5	Low.
95-100	95-100	90-100	70-80	0.06-0.20	6.1-6.5	High.
75-85	70-80	60-70	50-60	0.20-0.63	6.1-6.5	Low.
100	100	95-100	85-95	0.06-0.20	7.9-8.4	High.
80-90	70-80	20-40	10-20	0.63-2.00	6.6-7.3	Low.
60-70	55-65	50-60	40-50	0.06-0.20	6.6-7.3	High.
60-75	55-70	50-65	40-50	0.20-0.63	6.6-7.8	Moderate.

TABLE 9.—*Estimates of soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
Palomino: PaC.....	In. 12-20	In. 0-15 15	Sandy clay loam; very stony surface layer. Sandstone.	SC	A-6
Penthouse: PeC.....	>60	0-60	Gravelly and cobbly clay.....	CH	A-7
Retriever: ReC, RsD.....	6-20	0-9 9	Gravelly loam; very stony surface in places. Limestone.	SM	A-4
Rimrock: RtC.....	24-60	0-34 34	Clay; cobbly surface layer..... Tuff and ash.	CH	A-7
Sanchez: SaC.....	8-20	0-13 13-19 19	Extremely stony sandy loam..... Extremely stony sandy clay loam..... Sandstone.	SM SC	A-2 A-6
Siesta: ScB, SeD.....	0->60	0-5 5-40 40	Cobbly loam and loam..... Clay..... Basalt.	ML CH	A-4 A-7
*Soldier: SiC, SiE, SmF..... For McVickers part of SmF, see McVickers series.	>60	0-19 19-62	Cobbly loam..... Cobbly clay.....	CL CH	A-4 A-7
Sponseller: SnE.....	>60	0-17 17-43 43-52 52	Loam..... Clay loam..... Very gravelly clay loam..... Cinders.	ML CL GC	A-4 A-6 A-2
*Springerville: SpC, SrC, SsD..... For Gem part of SsD, see Gem series.	36->60	0-61 61	Clay; cobbly surface layer in places.... Basalt.	CH	A-7
Stony rough land, ash and tuff: St. No valid estimates can be made.					
Tortugas: ToD.....	4-18	0-13 13	Very stony loam..... Limestone.	SM	A-2
Waldroup: WaD.....	35->60	0-7 7-38 38	Gravelly silty clay loam..... Clay and gravelly clay..... Cinders.	CL CH	A-6 A-7
Wildcat: WcB, WdD.....	20-50	0-7 7-32 32	Gravelly fine sandy loam and loam; stony in places. Clay..... Sandstone.	ML CH	A-4 A-7
Winona: WnC.....	6-20	0-17 17	Gravelly loam..... Limestone.	SC	A-6

¹ Coarse fragments larger than 3 inches in diameter were discarded from all samples.

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Percentage passing sieve—1				Permeability	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200			
95-100	90-95	80-90	35-50	<i>In./hr.</i> 0.20-0.63	6.6-7.3	Moderate.
85-95	75-85	65-75	50-65	<0.06	7.9-8.4	High.
65-75	60-70	50-60	35-45	0.63-2.00	7.9-8.4	Low.
90-100	80-90	70-80	60-70	0.06-0.20	7.9-8.4	High.
90-100	80-90	60-70	25-35	0.63-2.00	6.6-7.3	Low.
90-100	80-90	65-75	35-50	0.63-2.00	6.6-7.3	Low.
85-95	75-85	60-70	50-60	0.63-2.00	6.6-7.3	Moderate.
95-100	95-100	80-90	70-80	0.06-0.20	6.6-7.8	High.
80-90	75-85	60-70	50-60	0.63-2.00	5.6-7.3	Low.
80-90	75-85	70-80	60-70	<0.06	4.5-6.0	High.
80-90	75-85	60-70	50-60	0.63-2.00	5.6-6.5	Moderate.
85-95	80-90	75-85	70-80	0.20-0.63	6.1-6.5	Moderate.
35-45	30-40	25-35	20-30	0.63-2.00	6.6-7.3	Low.
95-100	95-100	85-95	80-90	<0.06	7.4-8.4	High.
55-65	50-60	30-40	20-30	0.63-2.00	7.9-8.4	Low.
80-90	75-85	70-80	60-70	0.20-0.63	7.4-7.8	Moderate.
80-90	75-85	70-80	70-80	0.06-0.20	7.4-8.4	High.
80-90	75-85	65-75	50-60	0.63-2.00	6.6-7.3	Low.
95-100	90-95	80-90	70-80	<0.06	5.1-6.0	High.
70-80	65-75	60-70	40-50	0.63-2.00	7.9-8.4	Low.

TABLE 10.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils referring to other series that appear in

Soil series and map symbols	Suitability as a source of—		
	Topsoil	Sand and gravel	Road fill
Anthony: AnA-----	Fair: sandy loam-----	Poor for sand: 20 to 35 percent fines.	Good: A-2-----
Arizo----- Mapped only with Cowan soils.	Poor: sand and loamy sand; very gravelly below a depth of 18 inches.	Good for sand. Fair to good for gravel: 50 to 90 percent gravel.	Good: A-1-----
Basalt rock land: Ba. No interpretations.			
Bridge: BdC, BeD-----	Poor: cobbly surface; tuff at a depth of 22 to 40 inches.	Poor to unsuitable: 20 to 40 percent gravel; tuff at a depth of 22 to 40 inches.	Fair to poor: A-4 or A-6-----
Brolliar: B1B, BrC, BrD-----	Poor: clay in top 3 inches; stones and cobblestones.	Unsuitable: less than 20 percent gravel; clay in top 3 inches.	Poor: A-6 or A-7-----
Cabazon: CaF, CbD, CeD-----	Poor: bedrock at a depth of 8 to 20 inches.	Unsuitable: less than 20 percent gravel; bedrock at a depth of 8 to 20 inches.	Poor: A-7-----
Chilson: ChE-----	Poor: bedrock at a depth of 10 to 20 inches; cobblestones.	Unsuitable: gravelly clay at a depth of 3 inches; bedrock at a depth of 10 to 20 inches.	Poor: A-6-----
Clover Springs: ClB-----	Good: loam and silt loam-----	Unsuitable: less than 15 percent gravel, more than 50 percent passes the #200 sieve.	Fair: A-4-----
Cornville: CoB-----	Fair: sandy clay loam to a depth of 30 inches.	Poor for gravel: 30 to 40 percent gravel below a depth of 2½ feet. Poor for sand: 35 to 50 percent fines.	Fair: A-4-----
*Cowan: Cr----- For Arizo part of Cr, see Arizo series.	Poor: loamy sand and sand-----	Unsuitable for gravel: less than 25 percent gravel. Good for sand.	Good: A-2-----
Disterheff: DeE-----	Poor: clay at a depth of 3 inches.	Unsuitable: less than 15 percent gravel; clay at a depth of 3 inches.	Poor: A-7. Good below a depth of 3½ feet: A-2.
Dye: DfC, DvD-----	Poor: clay at a depth of 10 inches; bedrock at a depth of 10 to 20 inches.	Unsuitable: less than 25 percent gravel; clay at a depth of 10 inches.	Poor: A-6-----
Friana: FrA-----	Poor: clay loam and clay-----	Fair: 60 to 70 percent gravel below a depth of 28 inches. Unsuitable for sand.	Poor to a depth of 28 inches: A-7. Good below a depth of 28 inches: A-2.
Gem: GcD-----	Poor: cobblestones and clay at a depth of 10 inches.	Unsuitable: less than 25 percent gravel; 50 to 60 percent fines.	Poor: A-6 and A-7-----

interpretations

in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for the first column of this table]

Soil features affecting—			
Highway location	Farm ponds		Foundation for low buildings
	Reservoir area	Embankment	
0 to 2 percent slopes.....	Moderately rapid permeability; 0 to 2 percent slopes.	Medium strength, compacted permeability, and piping hazard.	Low shrink-swell potential; moderately rapid permeability.
Flood hazard; 0 to 2 percent slopes.	Very rapid permeability; 0 to 2 percent slopes.	High strength and compacted permeability; low piping hazard.	Low shrink-swell potential; very rapid permeability.
0 to 30 percent slopes; tuff at a depth of 22 to 40 inches.	0 to 30 percent slopes; tuff at a depth of 22 to 40 inches.	Medium to low strength, compacted permeability, and piping hazard.	Low to moderate shrink-swell potential; 0 to 20 percent slopes; bedrock at a depth of 22 to 40 inches.
0 to 30 percent slopes; high shrink-swell potential.	0 to 30 percent slopes; bedrock at a depth of 24 to 60 inches.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; stones and cobblestones; 30 percent slopes; bedrock at a depth of 24 to 60 inches.
Bedrock at a depth of 8 to 20 inches; 0 to 60 percent slopes.	0 to 60 percent slopes; bedrock at a depth of 8 to 20 inches.	Low strength, compacted permeability, and piping hazard.	Bedrock at a depth of 8 to 20 inches; high shrink-swell potential; 0 to 60 percent slopes.
Bedrock at a depth of 10 to 20 inches; 20 to 45 percent slopes.	20 to 45 percent slopes; bedrock at a depth of 10 to 20 inches.	Medium to low strength and piping hazard; low compacted permeability.	High shrink-swell potential; bedrock at a depth of 10 to 20 inches; 20 to 45 percent slopes.
Subject to flooding and frost heave; 0 to 5 percent slopes.	Moderate permeability; 0 to 5 percent slopes.	Medium to low strength and compacted permeability; high piping hazard.	Moderate shrink-swell potential; flooding hazard.
0 to 5 percent slopes.....	Moderate permeability below a depth of 2½ feet; 0 to 5 percent slopes.	Medium strength; low compacted permeability; medium piping hazard.	Moderate shrink-swell potential to a depth of 30 inches, low below a depth of 30 inches.
0 to 2 percent slopes.....	Rapid permeability; 0 to 2 percent slopes.	Medium strength and compacted permeability; medium to high piping hazard.	Shrink-swell potential low; possible water table overflow hazard.
20 to 45 percent slopes; high shrink-swell potential.	Slow permeability; 20 to 45 percent slopes.	Low to medium strength; low compacted permeability; low piping hazard.	High shrink-swell potential; 20 to 45 percent slopes.
Bedrock at a depth of 10 to 20 inches; 0 to 20 percent slopes; moderate to high shrink-swell potential.	10 to 20 percent slopes; bedrock at a depth of 10 to 20 inches.	Medium to low strength and piping hazard; low compacted permeability.	Moderate to high shrink-swell potential; 10 to 20 inches to bedrock.
Water ponds after snow melt or heavy rain; 0 to 2 percent slopes; high shrink-swell potential to a depth of 28 inches.	Permeability slow; 0 to 2 percent slopes.	Low to medium strength and piping hazard; low compacted permeability.	High shrink-swell potential; frequent water ponding.
Basalt at a depth of 22 to 40 inches; moderate shrink-swell potential; 0 to 20 percent slopes.	Permeability slow; 0 to 20 percent slopes; basalt at a depth of 22 to 40 inches.	Low strength, compacted permeability, and piping hazard.	Moderate shrink-swell potential; bedrock at a depth of 22 to 40 inches; 0 to 20 percent slopes.

TABLE 10.—*Engineer*

Soil series and map symbols	Suitability as a source of—		
	Topsoil	Sand and gravel	Road fill
Glendale: GdC, GeB.....	Fair: gravel on surface; silty clay loam or clay loam.	Unsuitable: less than 25 percent gravel; over 50 percent fines.	Poor: A-6.....
*Graham: GhD, GhF..... For House Mountain part of GhD and GhF, see House Mountain series.	Poor: cobbly; 10 to 20 inches to basalt.	Unsuitable: less than 25 percent gravel; 75 to 85 percent fines.	Poor: A-7.....
Guest: GuB.....	Poor: clay to a depth of 60 inches or more.	Unsuitable: less than 25 percent gravel; 75 to 95 percent fines.	Poor: A-7.....
Hantz: HaB.....	Poor: clay to a depth of 60 inches or more; gravelly surface.	Unsuitable: less than 25 percent gravel; 70 to 80 percent fines.	Poor: A-7.....
Hogg: HgD.....	Poor: clay at a depth of 8 inches.	Unsuitable: less than 25 percent gravel; 50 to 60 percent fines.	Poor: A-7.....
Hogg calcareous variant: HIC.	Poor: clay at a depth of 12 inches.	Unsuitable: less than 25 percent gravel; 60 to 80 percent fines.	Poor: A-6 and A-7.....
House Mountain: HmD.....	Poor: stony and gravelly loam.	Unsuitable: shallow to bedrock; limited material; 35 to 50 percent fines.	Fair: A-4.....
*Jacks: JaD, JtD, JtE..... For Tortugas part of JtD and JtE, see Tortugas series.	Poor: clay at a depth of 7 inches.	Unsuitable: less than 25 percent gravel; 70 to 80 percent fines.	Poor: A-6 and A-7.....
Limestone and sandstone rock land: Ls. No interpretations.			
Luth: LuB.....	Poor: heavy clay loam or clay..	Unsuitable: less than 25 percent gravel; 70 to 80 percent fines.	Poor: A-7.....
Lynx: LyB.....	Good to fair: fine sandy loam and clay loam.	Unsuitable: less than 25 percent gravel; 40 to 80 percent fines.	Fair to poor: A-6 and A-4.
*McVickers: McC, MhC, MhD. For Hogg part of MhC and MhD, see Hogg series.	Good: very fine sandy loam to a depth of 16 inches. Poor: clay at a depth of 16 inches.	Unsuitable: less than 25 percent gravel; 50 to 80 percent fines.	Fair to a depth of 16 inch A-4. Poor below a depth of 16 inch A-6 and A-7.
Navajo: NaB.....	Poor: clay to a depth of 60 inches and more.	Unsuitable: less than 25 percent gravel; 85 to 95 percent fines.	Poor: A-7.....
Overgaard: OvD.....	Poor: dominantly gravelly clay..	Unsuitable: less than 25 percent gravel; 40 to 50 percent fines.	Good to a depth of 10 inch A-2. Poor at a depth of 10 to inches: A-7 and A-6.
Palomino: PaC.....	Poor: very stony; bedrock at a depth of 12 to 20 inches.	Unsuitable: less than 25 percent gravel. Poor for sand: 35 to 50 percent fines.	Poor: A-6.....

interpretations—Continued

Highway location	Soil features affecting—		Foundation for low buildings
	Farm ponds		
	Reservoir area	Embankment	
Moderate shrink-swell potential; 0 to 10 percent slopes.	Permeability moderately slow; 0 to 10 percent slopes.	Medium to low strength and piping hazard; low compacted permeability.	Moderate shrink-swell potential; 0 to 10 percent slopes.
10 to 20 inches to bedrock; high shrink-swell potential; 0 to 60 percent slopes.	0 to 60 percent slopes; bedrock at a depth of 10 to 20 inches.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; 10 to 20 inches to bedrock; 0 to 60 percent slopes.
High shrink-swell potential; 0 to 5 percent slopes.	Permeability slow; 0 to 5 percent slopes.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 5 percent slopes.
High shrink-swell potential; 0 to 5 percent slopes.	Permeability very slow; 0 to 5 percent slopes.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 5 percent slopes.
High shrink-swell potential; 0 to 20 percent slopes.	Permeability slow; bedrock at a depth of 24 to 60 inches.	Low strength, compacted permeability, and piping hazard.	10 to 20 percent slopes; high shrink-swell potential; bedrock at a depth of 24 to 60 inches.
High shrink-swell potential; 0 to 10 percent slopes.	Permeability very slow; 0 to 10 percent slopes.	Low strength, and compacted permeability; low to medium piping hazard.	High shrink-swell potential; 0 to 10 percent slopes.
0 to 60 percent slopes; 4 to 14 inches to bedrock.	0 to 60 percent slopes; bedrock at a depth of 4 to 14 inches.	Medium strength; medium to low compacted permeability; medium to high piping hazard.	0 to 60 percent slopes; 4 to 14 inches to bedrock.
0 to 45 percent slopes; high shrink-swell potential; bedrock at a depth of 20 to 50 inches.	Permeability slow; 0 to 45 percent slopes; bedrock at a depth of 20 to 50 inches.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 45 percent slopes; bedrock at a depth of 20 to 50 inches.
Frequent flooding; high shrink-swell potential; 0 to 5 percent slopes.	Permeability slow; 0 to 5 percent slopes.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; frequent flooding; 0 to 5 percent slopes.
Frequent flooding; moderate shrink-swell potential; 0 to 5 percent slopes.	Permeability moderately slow; 0 to 5 percent slopes.	Medium strength; medium to low compacted permeability and piping hazard.	Moderate shrink-swell potential; frequent flooding; 0 to 5 percent slopes.
Slow permeability; high shrink-swell potential in subsoil; 0 to 30 percent slopes.	Permeability slow; 0 to 30 percent slopes; bedrock at a depth of 30 to 60 inches.	Medium to low strength and piping hazard; low compacted permeability.	High shrink-swell potential in subsoil; 0 to 30 percent slopes; bedrock at a depth of 30 to 60 inches.
Flood hazard; high shrink-swell potential; 0 to 5 percent slopes.	Permeability very slow; 0 to 5 percent slopes.	Medium to low strength and piping hazard; low compacted permeability.	High shrink-swell potential; flood hazard; 0 to 5 percent slopes.
Moderate to high shrink-swell potential; 0 to 20 percent slopes.	Permeability slow; 0 to 20 percent slopes.	Medium strength; low compacted permeability; medium to low piping hazard.	High shrink-swell potential at a depth of 10 to 38 inches, moderate below a depth of 38 inches; 0 to 20 percent slopes.
0 to 15 percent slopes; moderate shrink-swell potential.	0 to 15 percent slopes; bedrock at a depth of 12 to 20 inches.	Medium strength; low compacted permeability; medium to low piping hazard.	12 to 20 inches to bedrock; stony surface; moderate shrink-swell potential.

TABLE 10.—*Engineering*

Soil series and map symbols	Suitability as a source of—		
	Topsoil	Sand and gravel	Road fill
Penthouse: PeC.....	Poor: cobblestones; clay at a depth of 5 inches.	Unsuitable: less than 25 percent gravel; 50 to 65 percent fines.	Poor: A-7.....
Retriever: ReC, RsD.....	Poor: bedrock at a depth of 6 to 20 inches; stony loam.	Poor: less than 50 percent gravel; 35 to 45 percent fines.	Fair: A-4.....
Rimrock: RtC.....	Poor: cobbly clay.....	Unsuitable: less than 25 percent gravel; 60 to 70 percent fines.	Poor: A-7.....
Sanchez: SaC.....	Poor: extremely stony; bedrock at a depth of 8 to 20 inches.	Unsuitable: less than 20 percent gravel; bedrock at a depth of 8 to 20 inches.	Good to poor: A-2 and A-6...
Siesta: ScB, SeD.....	Poor: clay at a depth of 5 inches; cobbly in places.	Unsuitable: less than 25 percent gravel; 70 to 80 percent fines.	Poor: A-7.....
*Soldier: S/C, S/E, SmF..... For McVickers part of SmF, see McVickers series.	Poor: cobbly.....	Unsuitable: less than 25 percent gravel; 50 to 70 percent fines.	Fair to poor: A-4 and A-7.....
Sponseller: SnE.....	Fair: gravelly; silt loam and loam.	Good for gravel: cinders at a depth of 30 to 60 inches; 50 to 80 percent fines.	Fair to poor: A-4 and A-6.....
*Springerville: SpC, SrC, SsD. For Gem part of SsD, see Gem series.	Poor: clay; cobbly in places...	Unsuitable: less than 25 percent gravel; 80 to 90 percent fines.	Poor: A-7.....
Stony rough land, ash and tuff: St. No interpretations.			
Tortugas: ToD.....	Poor: very stony loam.....	Unsuitable: bedrock at a depth of 4 to 18 inches.	Good.....
Waldroup: WaD.....	Poor: clay at a depth of 7 inches; gravelly surface.	Unsuitable to a depth of 38 inches. Good below a depth of 38 inches; cinders; 60 to 80 percent fines to a depth of 38 inches.	Poor to a depth of 38 inches: CL, A-6, and A-7. Good below a depth of 38 inches: cinders.
Wildcat: WcB, WdD.....	Poor: clay at a depth of 7 inches; gravelly and stony.	Unsuitable: less than 25 percent gravel; 60 to 80 percent fines.	Fair to poor: A-4 and A-7.....
Winona: WnC.....	Poor: gravelly loam; bedrock at a depth of 6 to 20 inches.	Unsuitable: bedrock at a depth of 6 to 20 inches.	Poor: A-6.....

interpretations—Continued

Soil features affecting—			
Highway location	Farm ponds		Foundation for low buildings
	Reservoir area	Embankment	
0 to 10 percent slopes; high shrink-swell potential.	Permeability very slow; 0 to 10 percent slopes.	Low strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 10 percent slopes.
0 to 30 percent slopes; 6 to 20 inches to bedrock.	0 to 30 percent slopes; 6 to 20 inches to bedrock.	Medium strength and compacted permeability; medium to high piping hazard.	0 to 30 percent slopes; 6 to 20 inches to bedrock.
Slow permeability; 0 to 10 percent slopes.	Slow permeability; bedrock at a depth of 24 to 60 inches.	Low shear strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 10 percent slopes.
Extremely stony; bedrock at a depth of 8 to 20 inches; 0 to 15 percent slopes.	Fractured bedrock at a depth of 8 to 20 inches; 0 to 15 percent slopes.	Medium shear strength and piping hazard; medium to low compacted permeability.	Low shrink-swell potential; bedrock at a depth of 8 to 20 inches; 0 to 15 percent slopes.
Cobbly in places; high shrink-swell potential; bedrock at a depth of 36 to 60 inches.	Bedrock at a depth of 3 to 5 feet; slow permeability.	Low shear strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 2 percent slopes; bedrock at a depth of 36 to 60 inches.
Cobbly; 0 to 60 percent slopes; high shrink-swell potential.	Very slow permeability; 0 to 60 percent slopes.	Low shear strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 60 percent slopes.
10 to 40 percent slopes; moderate shrink-swell potential.	Moderately slow permeability; 10 to 40 percent slopes.	Low to medium shear strength and compacted permeability; medium piping hazard.	Moderate shrink-swell potential; 10 to 40 percent slopes.
High shrink-swell potential; cobbly in places; 0 to 20 percent slopes.	Very slow permeability; basalt rock at a depth of 36 to 60 inches or more.	Low shear strength, compacted permeability, and piping hazard.	High shrink-swell potential; 0 to 20 percent slopes.
0 to 30 percent slopes; bedrock at a depth of 4 to 18 inches.	Bedrock at a depth of 4 to 18 inches; 0 to 30 percent slopes.	Medium shear strength; medium to low compacted permeability; medium piping hazard.	Bedrock at a depth of 4 to 18 inches; 0 to 30 percent slopes.
Slopes to 30 percent; cinders at a depth of 3 to 4 feet.	Cinders at a depth of 3 to 4 feet; moderately slow to slow permeability; 5 to 30 percent slopes.	Low shear strength, compacted permeability, and piping hazard.	High shrink-swell potential; 5 to 30 percent slopes.
Somewhat poorly drained; stony and cobbly in places; 0 to 20 percent slopes; bedrock at a depth of 20 to 50 inches.	Very slow permeability; cobbly and stony in places; bedrock at a depth of 20 to 50 inches.	Low shear strength, compacted permeability, and piping hazard.	High shrink-swell potential; somewhat poorly drained; 0 to 20 percent slopes.
Bedrock at a depth of 6 to 20 inches; 0 to 10 percent slopes.	Bedrock at a depth of 6 to 20 inches; 0 to 10 percent slopes.	Medium shear strength; low compacted permeability; medium to low piping hazard.	Low shrink-swell potential; bedrock at a depth of 6 to 20 inches; 0 to 10 percent slopes.

TABLE 11.—*Engineering*

[Tests performed by the Arizona Highway Department in accordance with

Soil name and location	Parent material	Arizona report No. 62	Depth	Moisture- density ¹		Mechanical analysis ²			
				Maxi- mum dry density	Opti- mum mois- ture	Percentage passing sieve—			
						2- inch	1½- inch	1- inch	¾- inch
Friana loam: Center of sec. 22, T. 15 N., R. 9 E. (Modal).	Cinder, ash, and alluvium from basalt.	27124 27125	In. 8-17 31-44	Lb./cu. ft. 96 93	Pct. 24 28				
Hogg loam: SW¼NE¼ sec. 12, T. 14 N., R. 9 E. (Modal).	Hard conglomerate-----	27132	3-20	95	24				100
McVickers very fine sandy loam: NW¼ sec. 31, T. 14 N., R. 10 E. (Modal).	Sandstone member of Kai- bab Formation.	27121 27122 27123	4-15 20-28 40-60	112 105 111	12 19 16		100	98	97
						100	99	100	99
Navajo clay: 1,050 feet W. and 1,320 feet S. of NE. corner of sec. 23, T. 20 N., R. 15 E.	Recent alluvium-----	27146	5-19	101	22				
Soldier cobbly loam: SE¼SW¼ sec. 22, T. 13 N., R. 10 E. (Modal).	Cherty limestone of Kaibab Formation.	27135 27136 27137	3-17 17-36 36-50	112 95	14 24 27	100 100 100	98 96 98	91 89 92	88 85 89
Wildcat gravelly loam: SW¼ sec. 10, T. 12 N., R. 8 E. (Modal).	Coconino Sandstone-----	27131	14-24	94	26				
Winona gravelly loam: 1,800 feet S. and 500 feet E. of NW. corner of sec. 35, T. 29 N., R. 1 E.	Dolomitic limestone mem- ber of Kaibab Forma- tion.	27142	2-12	102	19	95	89	80	78

¹ Based on AASHO Designation: T 99-70, Method A (I).² Mechanical analysis according to AASHO Designation: T 88-70 (I). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser

test data

standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis ² —Continued								Liquid limit	Plastic- ity index	Classification	
Percentage passing sieve—Continued					Percentage smaller than—					AASHO	Unified
$\frac{3}{8}$ - inch	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.02 mm.	0.005 mm.	0.001 mm.				
			100	99	68	34	20	<i>Pct.</i> 46	27	A-7-6(16)	CL
		100	97	91	67	50	39	63	45	A-7-6(20)	CH
98	96	93	83	58	55	51	49	71	55	A-7-6(16)	CH
95	94	91	88	54	20	17	3	³ NP	NP	A-4(4)	ML
99	99	99	97	64	48	41	34	45	33	A-7-6(15)	CL
93	92	91	87	55	32	25	19	33	22	A-6(9)	CL
			100	98	96	82	50	44	27	A-7-6(16)	CL.
84	83	77	72	56	32	15	8	28	8	A-4(4)	CL
78	74	69	65	62	52	48	43	95	74	A-7-6(16)	CH
87	85	84	83	72	54	52	40	79	61	A-7-6(19)	CH
		100	92	71	71	62	52	82	67	A-7-6(19)	CH
76	75	69	65	44	26	12	7	36	14	A-6(3)	SC

than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

³ Nonplastic.

⁴ Laboratory test data not corrected for estimated 35 percent larger than 3 inches that was discarded in field sampling. 100 percent passes 3-inch sieve.

Capability Grouping

The soils of the Long Valley Area are not generally used for tilled crops because they are mostly within forested areas. The suitability of each soil for producing tilled crops, however, is indicated in the Guide to Mapping Units, where the capability grouping of each soil is shown.

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slopes, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are described in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, or water supply, or to use for esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture or range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses.

The Long Valley Area is wholly within the Coconino National Forest. Use of the soils for production of commercial crops is negligible. For this reason, the soils have been grouped only into classes and subclasses. No soils are in classes I, II, III, IV, or V; but some, generally those along the Verde River, would be suitable for annual or periodic cultivation if irrigated. Other soils in the area are suitable for certain special crops.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called *ped*s. Clods are aggregates produced by tillage or logging.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Aspect (forestry). The direction toward which a slope faces. Synonym: Exposure.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Cobblestone. A rounded or partly rounded fragment of rock, 3 to 10 inches in diameter.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Exposure (forestry). The direction toward which a slope faces. Synonym: Aspect.

Gravelly soil material. From 15 to 50 percent of material, by volume, consists of rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or

true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Igneous rock. Rock that has been formed by the cooling of molten mineral material. Examples: Granite, syenite, diorite, and gabbro.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Krotovinas. Tubes or streaks within a soil layer that have been filled with material from some other layer. Krotovinas appear as rounded spots of various sizes. They are holes dug by burrowing animals and later filled with soil material.

Landscape. All the characteristics that distinguish a certain kind of area on the earth's surface and give it a distinguishing pattern, in contrast to other kinds of areas. Any one kind of soil is said to have a characteristic natural landscape, and under different uses it has one or more characteristic cultural landscapes.

Mapping unit. Any soil, miscellaneous land type, soil complex, soil association, or undifferentiated soil group shown on a soil map and identified by a symbol.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; or that are too nearly inaccessible for orderly examination; or that occur where, for other reasons, it is not feasible to classify the soil.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid, and very rapid.*

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil series, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

Productivity (soil). The present capability of a soil for producing a specified plant or sequence of plants under a specified system of management. It is measured in terms of output, or harvest, in relation to input of production for the specific kind of soil under a specified system of management.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		pH
Extremely acid....	Below 4.5	Mildly alkaline.....	7.4 to 7.8
Very strongly acid..	4.5 to 5.0	Moderately alkaline..	7.9 to 8.4
Strongly acid.....	5.1 to 5.5	Strongly alkaline.....	8.5 to 9.0
Medium acid.....	5.6 to 6.0	Very strongly alkaline	
Slightly acid.....	6.1 to 6.5	line	9.1 and higher
Neutral.....	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Sedimentary rock. A rock composed of particles deposited from suspension in water. The chief sedimentary rocks are conglomerate, from gravel; sandstone, from sand; shale, from clay; and limestone, from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sands have been consolidated into sandstone.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in characteristics and in arrangement in the profile.

Shrink-swell potential (engineering). Amount that a soil will expand when wet or contract when dry. Usually it is an indication of the kind and amount of clay in soil.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slash. Debris left after logging, pruning, thinning, or brush cutting; also debris left by wind or fire.

Slope. The inclination of the soil surface from the horizontal; percentage of slope is the vertical distance, divided by the horizontal distance, multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other

plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Topsoil. A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Trick tank. An artificial watershed that catches rainfall or snow that drains into a catchment basin. Water from the basin is piped to troughs and used by livestock and wildlife during dry periods.

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SOIL MANAGEMENT AREAS*

- 1 Siesta Sponseller area: Nearly level to steep, well-drained soils that have a clay or clay loam subsoil; formed over basalt and cinders
- 2 Brilliant area: Nearly level to moderately steep, well-drained soils that have a cobbly clay subsoil; formed over basalt
- 3 Luth-Clover Springs area: Nearly level to very gently sloping, well-drained clay loams and loams; formed in alluvium
- 4 Springerville-Gem area: Nearly level to strongly sloping, well-drained clays; formed over basalt and cinders
- 5 Soldier-McVickers area: Nearly level to steep, well drained and moderately well drained soils that have a clay or cobbly clay subsoil; formed over limestone and sandstone
- 6 Hogg-Jacks-Wildcat area: Gently sloping to moderately steep, well drained and somewhat poorly drained soils that have a clay, clay loam, or sandy clay loam subsoil; formed over limestone and sandstone
- 7 Tortugas-Winona-Retriever area: Nearly level to moderately steep, well-drained loams; less than 20 inches deep to limestone
- 8 Graham-House Mountain area: Nearly level to steep, well-drained loams and clays; less than 20 inches deep to basalt
- 9 Glendale-Anthony area: Nearly level to gently sloping, well-drained silty clay loams and sandy loams; on flood plains and low terraces
- 10 Stony rough land-Rock land area: Steep and very steep stony rough land

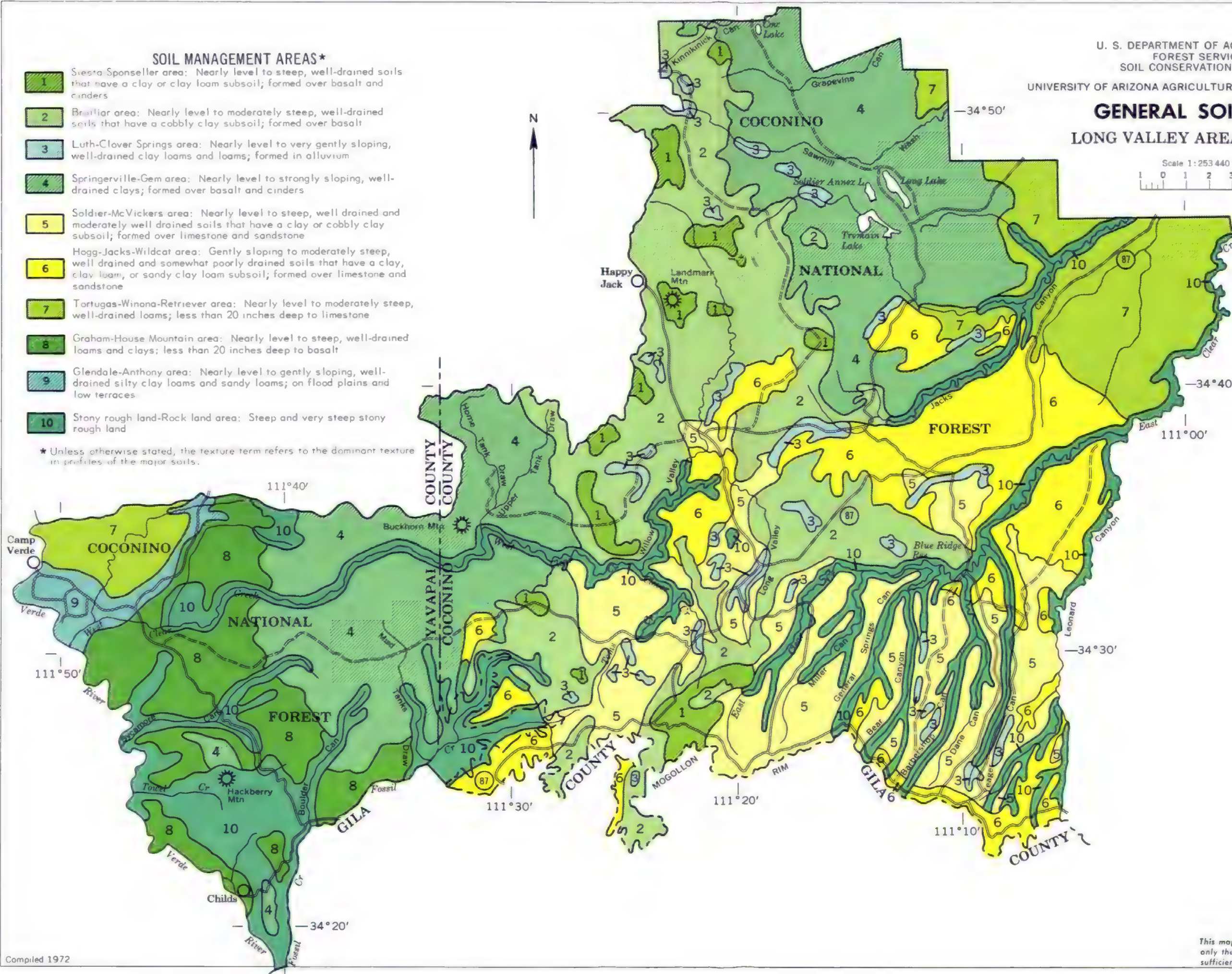
* Unless otherwise stated, the texture term refers to the dominant texture in profiles of the major soils.

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FOREST SERVICE
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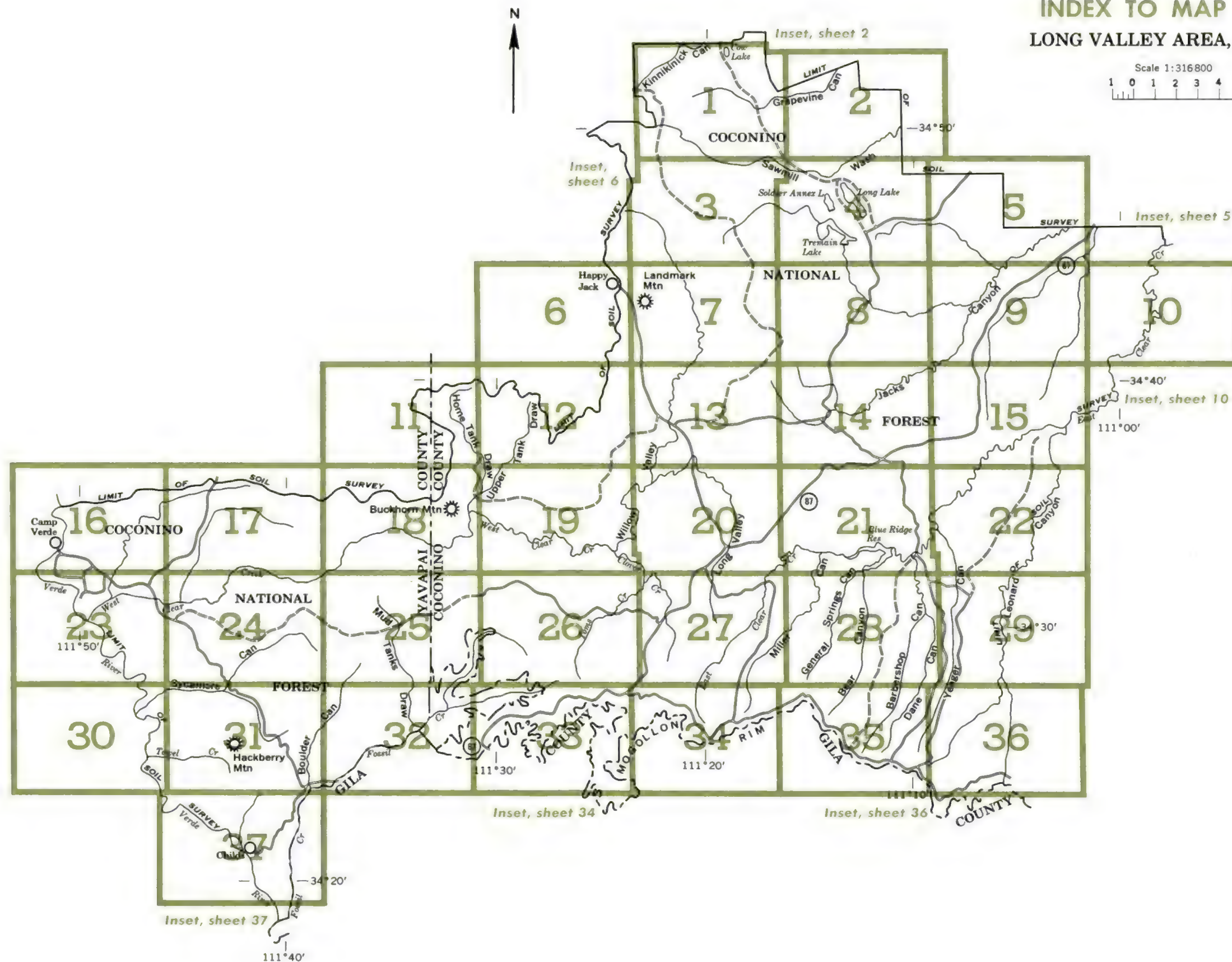
GENERAL SOIL MAP LONG VALLEY AREA, ARIZONA

Scale 1:253,440
1 0 1 2 3 4 Miles



INDEX TO MAP SHEETS LONG VALLEY AREA, ARIZONA

Scale 1:316800
1 0 1 2 3 4 5 Miles



SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Symbols without a slope letter are those of soils or land types that have a considerable range of slope.

SYMBOL	NAME
AnA	Anthony fine sandy loam, 0 to 2 percent slopes
Ba	Basalt rock land
BdC	Bridge gravelly sandy loam, 0 to 15 percent slopes
BeD	Bridge cobbly loam, 10 to 30 percent slopes
BlB	Bralliar clay loam, 0 to 5 percent slopes
BrC	Bralliar very stony clay loam, 0 to 10 percent slopes
BrD	Bralliar very stony clay loam, 10 to 30 percent slopes
CaF	Cabazon cobbly clay loam, 20 to 60 percent slopes
CbD	Cabazon very stony clay loam, 0 to 20 percent slopes
CeD	Cabazon extremely rocky loam, 0 to 20 percent slopes
ChE	Chilson cobbly clay loam, 20 to 45 percent slopes
ClB	Clover Springs silt loam, 0 to 5 percent slopes
CoB	Cornville fine sandy loam, 0 to 5 percent slopes
Cr	Cowan and Arizo soils
DeE	Disterheff very stony clay loam, 20 to 45 percent slopes
DfC	Dye fine sandy loam, 0 to 10 percent slopes
DvD	Dye very stony fine sandy loam, 0 to 20 percent slopes
FrA	Friana clay loam, 0 to 2 percent slopes
GcD	Gem cobbly clay loam, 0 to 20 percent slopes
GdC	Glendale gravelly fine sandy loam, 0 to 10 percent slopes
GeB	Glendale gravelly silt loam, 0 to 5 percent slopes
GhD	Graham and House Mountain soils, 0 to 30 percent slopes
GhF	Graham and House Mountain soils, 30 to 60 percent slopes
GuB	Guest clay, 0 to 5 percent slopes
HaB	Hantz gravelly silty clay, 0 to 5 percent slopes
HgD	Hagg fine sandy loam, 0 to 20 percent slopes
HlC	Hagg loam, calcareous variant, 0 to 10 percent slopes
HmD	House Mountain stony loam, 0 to 30 percent slopes
JaD	Jacks fine sandy loam, 0 to 20 percent slopes
JtD	Jacks-Tartugas extremely rocky complex, 0 to 20 percent slopes
JtE	Jacks-Tartugas extremely rocky complex, 20 to 45 percent slopes
Ls	Limestone and sandstone rock land
LuB	Luth clay loam, 0 to 5 percent slopes
LyB	Lynx fine sandy loam, 0 to 5 percent slopes
McC	McVickers very fine sandy loam, 0 to 10 percent slopes
MhC	McVickers-Hogg complex, 0 to 10 percent slopes
MhD	McVickers-Hogg complex, 10 to 30 percent slopes
NaB	Navajo silty clay, 0 to 5 percent slopes
OvD	Overgaard sandy loam, 0 to 20 percent slopes
PaC	Palomino very stony fine sandy loam, 0 to 15 percent slopes
PeC	Penthouse cobbly loam, 0 to 10 percent slopes
ReC	Retriever loam, 0 to 10 percent slopes
RsD	Retriever very stony loam, 0 to 30 percent slopes
RtC	Rimrock cobbly clay, 0 to 10 percent slopes
SaC	Sanchez extremely stony sandy loam, 0 to 15 percent slopes
ScB	Siesta loam, 0 to 5 percent slopes
SeD	Siesta cobbly loam, 0 to 20 percent slopes
SlC	Soldier cobbly loam, 0 to 10 percent slopes
SlE	Soldier cobbly loam, 20 to 45 percent slopes
SmF	Soldier-McVickers very rocky complex, 20 to 60 percent slopes
SnE	Sponseller gravelly silt loam, 10 to 40 percent slopes
SpC	Springerville clay, 0 to 10 percent slopes
ScC	Springerville cobbly clay, 0 to 10 percent slopes
SsD	Springerville-Gem complex, 0 to 20 percent slopes
St	Stony rough land, ash and tuff
ToD	Tortugas very stony loam, 0 to 30 percent slopes
WaD	Waldroup gravelly silty clay loam, 5 to 30 percent slopes
WcB	Wildcat gravelly fine sandy loam, 0 to 5 percent slopes
WdD	Wildcat very rocky loam, 0 to 20 percent slopes
WnC	Winona gravelly loam, 0 to 10 percent slopes

WORKS AND STRUCTURES

Highways and roads	
Dual	
Good motor	
Poor motor	
Trail	
Highway markers	
National Interstate	
U. S.	
State or county	
Railroads	
Single track	
Multiple track	
Abandoned	
Bridges and crossings	
Road	
Trail	
Railroad	
Ferry	
Ford	
Grade	
R. R. over	
R. R. under	
Tunnel	
Buildings	
School	
Church	
Mine and quarry	
Gravel pit	
Power line	
Pipeline	
Cemetery	
Dams	
Levee	
Tanks	
Well, oil or gas	
Forest fire or lookout station	
Windmill	

CONVENTIONAL SIGNS

BOUNDARIES	
National or state	
County	
Project area	
Reservation	
Land grant	
Small park, cemetery, airport	
DRAINAGE	
Streams, double-line	
Perennial	
Intermittent	
Streams, single-line	
Perennial	
Intermittent	
Crossable with tillage implements	
Not crossable with tillage implements	
Unclassified	
Canals and ditches	
Lakes and ponds	
Perennial	
Intermittent	
Spring	
Marsh or swamp	
Wet spot	
Alluvial fan	
Drainage end	

RELIEF

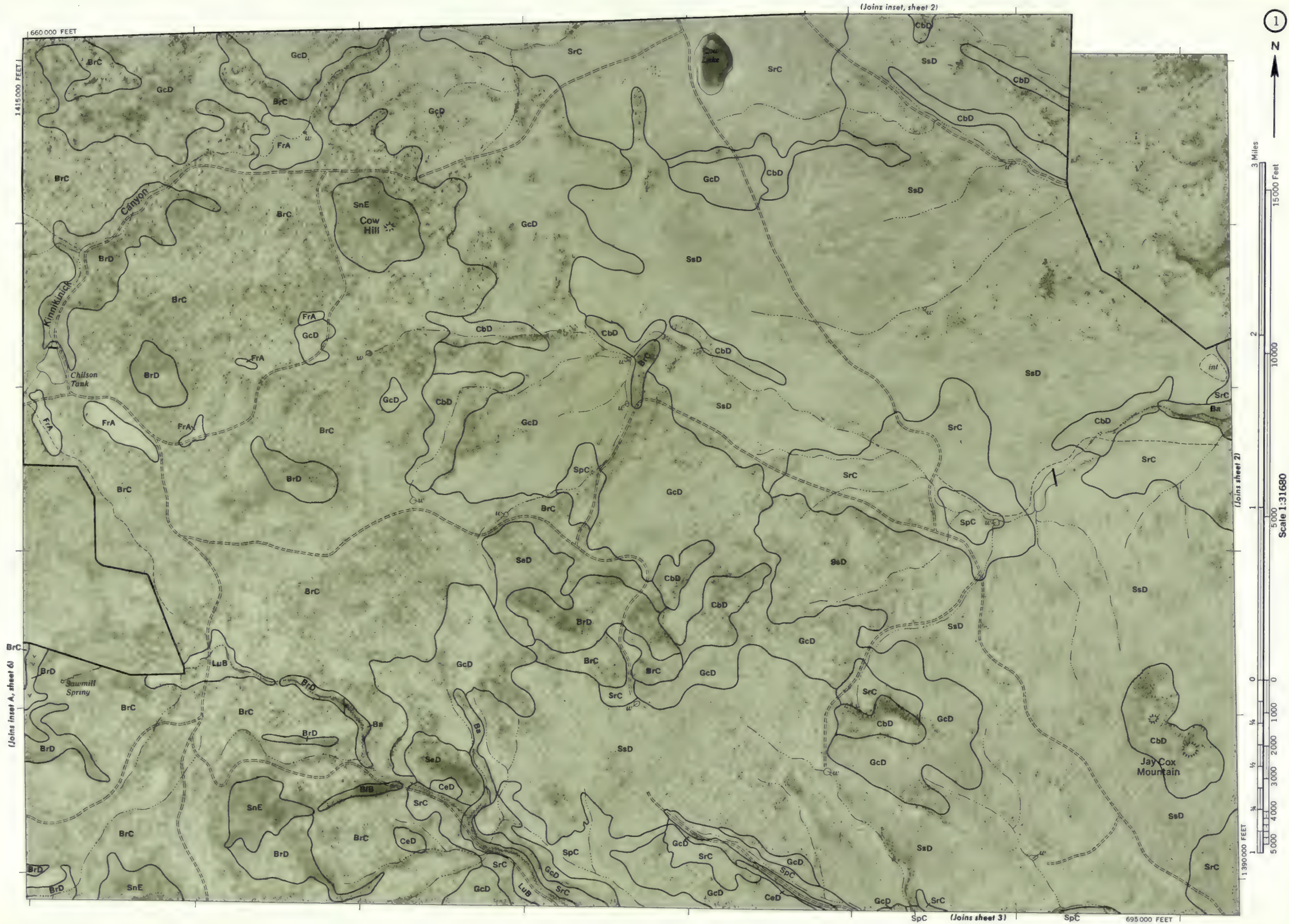
Escarpments	
Bedrock	
Other	
Prominent peak	

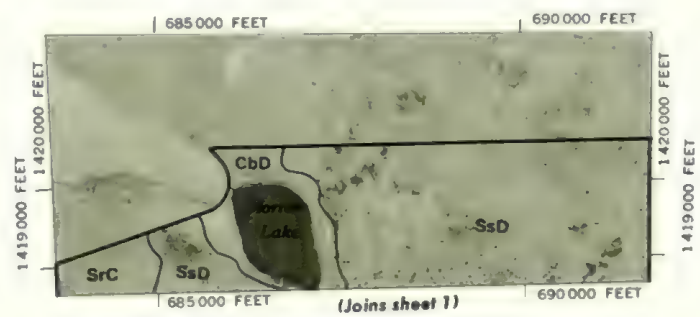
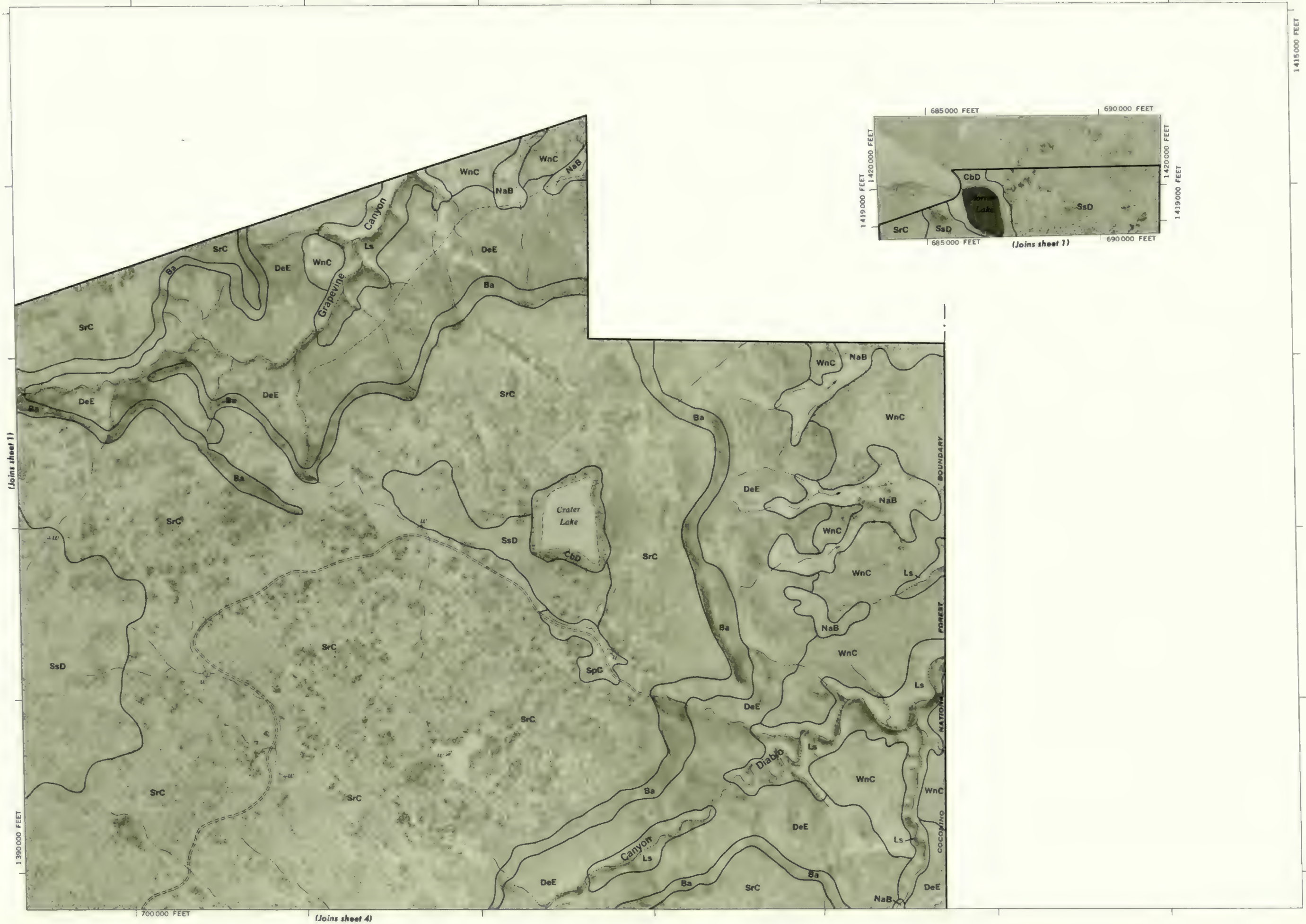
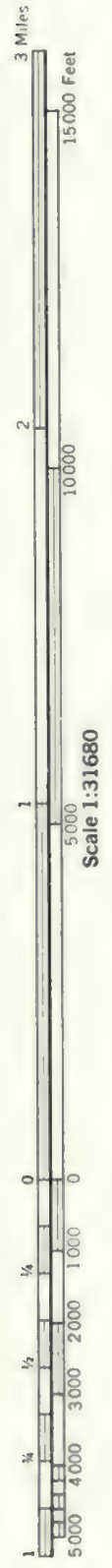
SOIL SURVEY DATA

Soil boundary	
and symbol	
Gravel	
Stoniness	
Very stony	
Rock outcrops	
Chert fragments	
Clay spot	
Sand spot	
Gumbo or scabby spot	
Made land	
Severely eroded spot	
Blowout, wind erosion	
Gully	
Soil sample site	

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LONG VALLEY AREA, ARIZONA — SHEET NUMBER 1

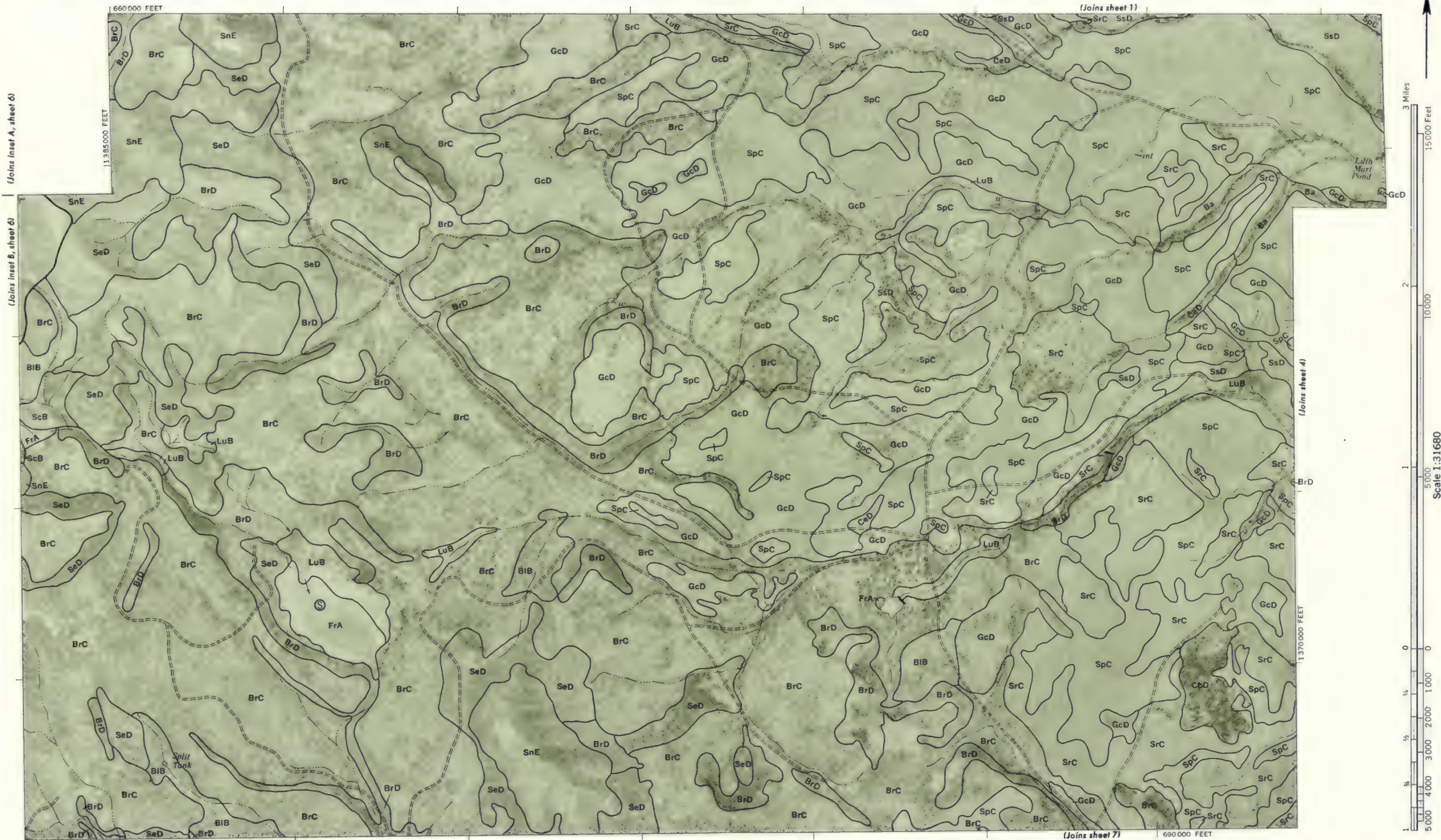


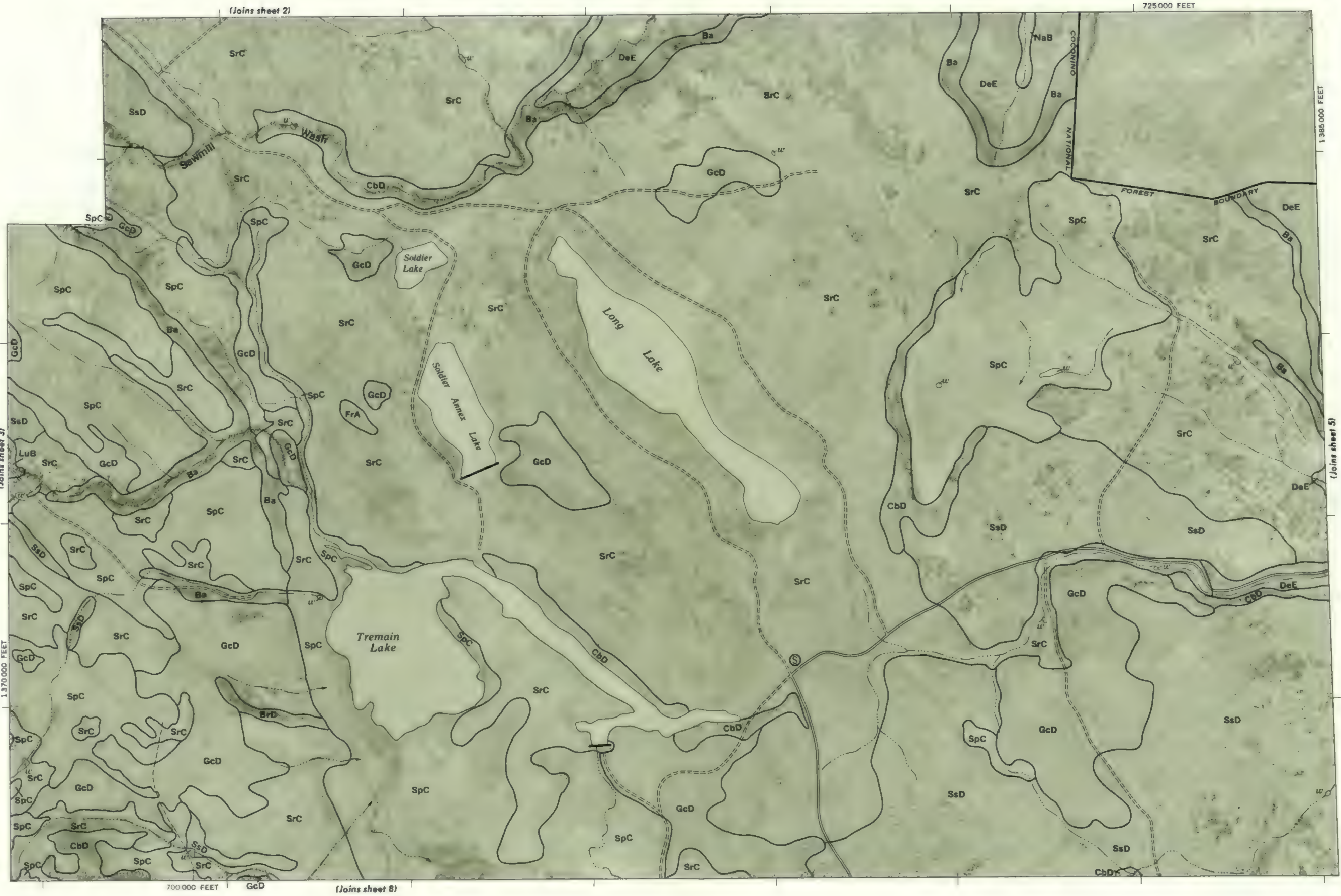


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LONG VALLEY AREA, ARIZONA NO. 3

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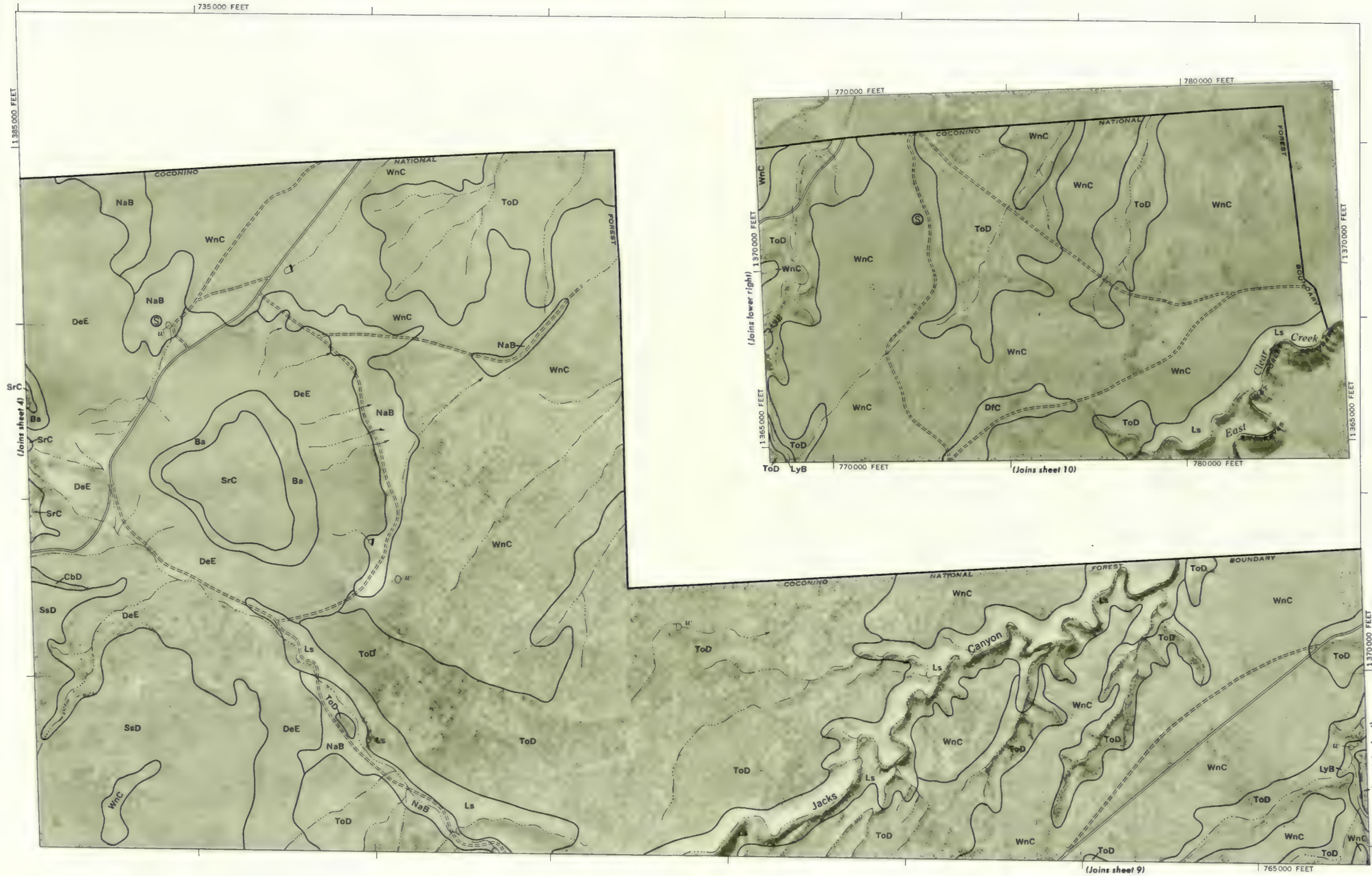


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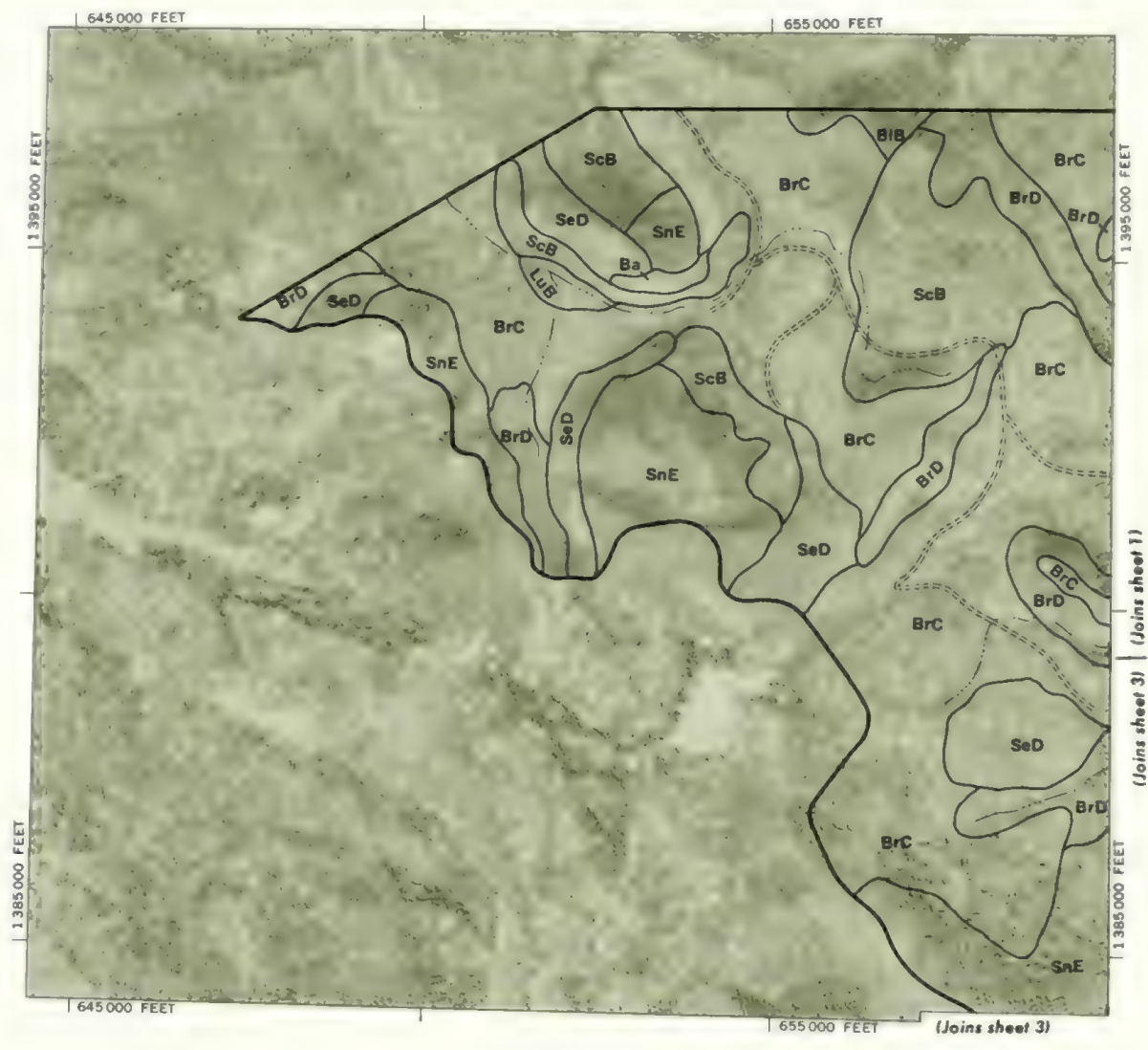
LONG VALLEY AREA, ARIZONA NO. 5

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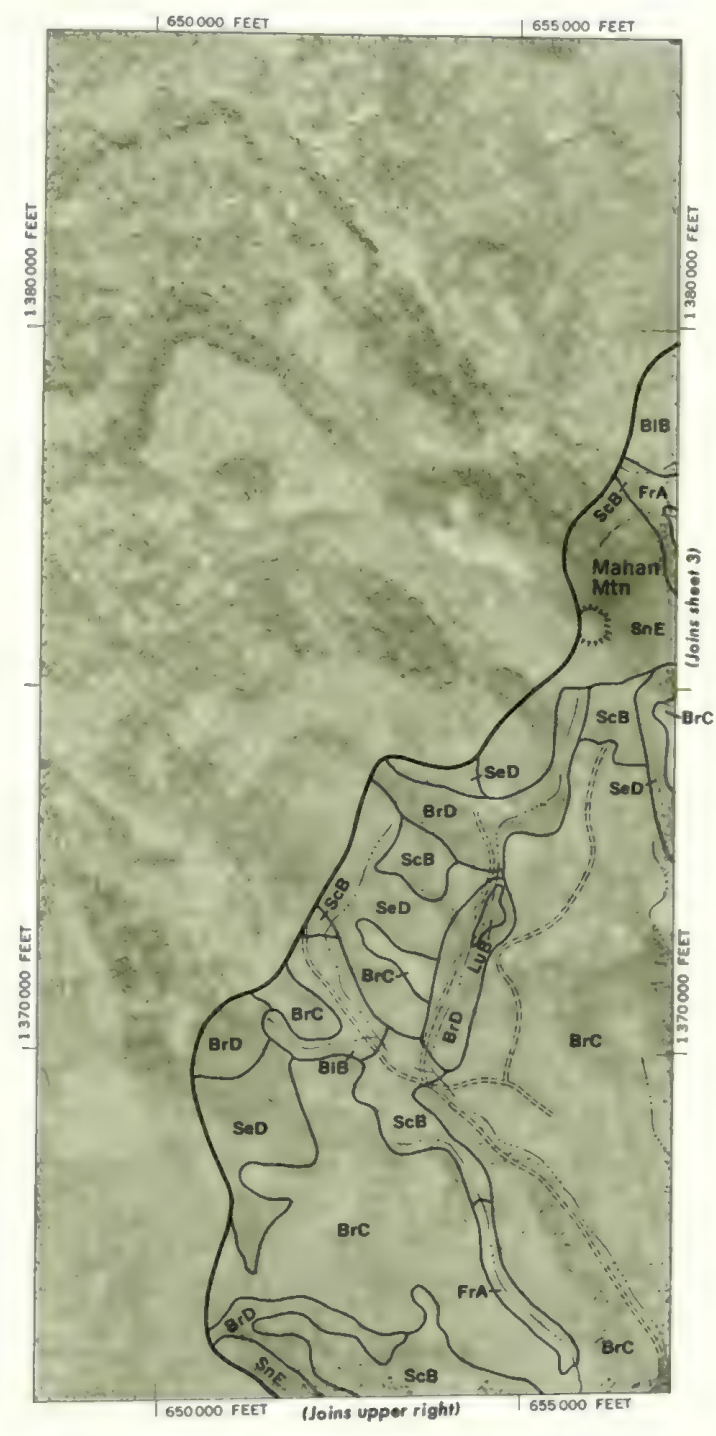




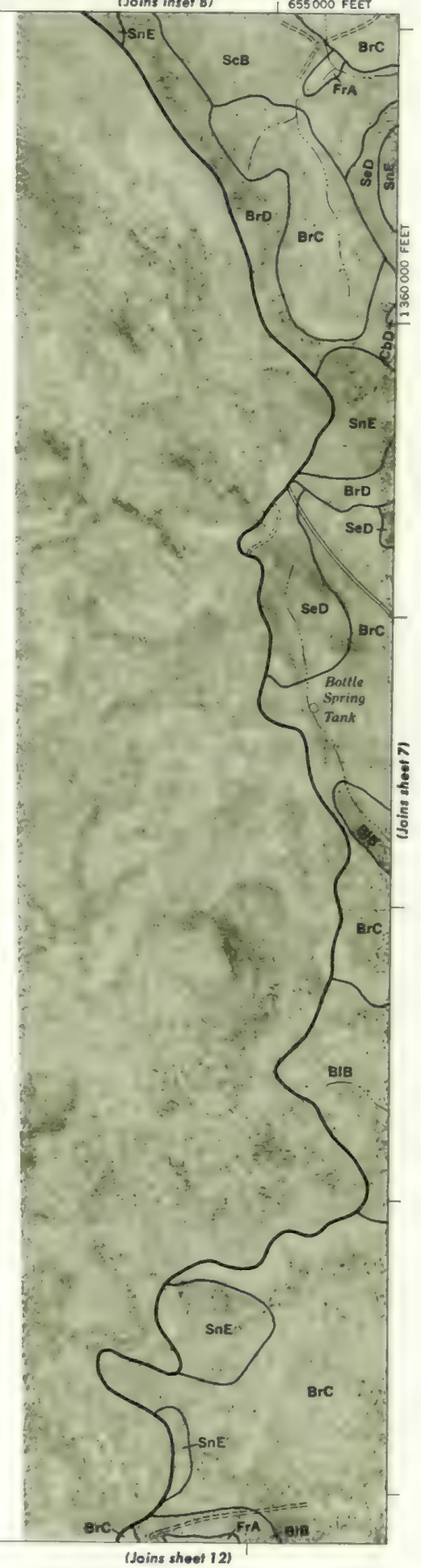
INSET A



INSET B



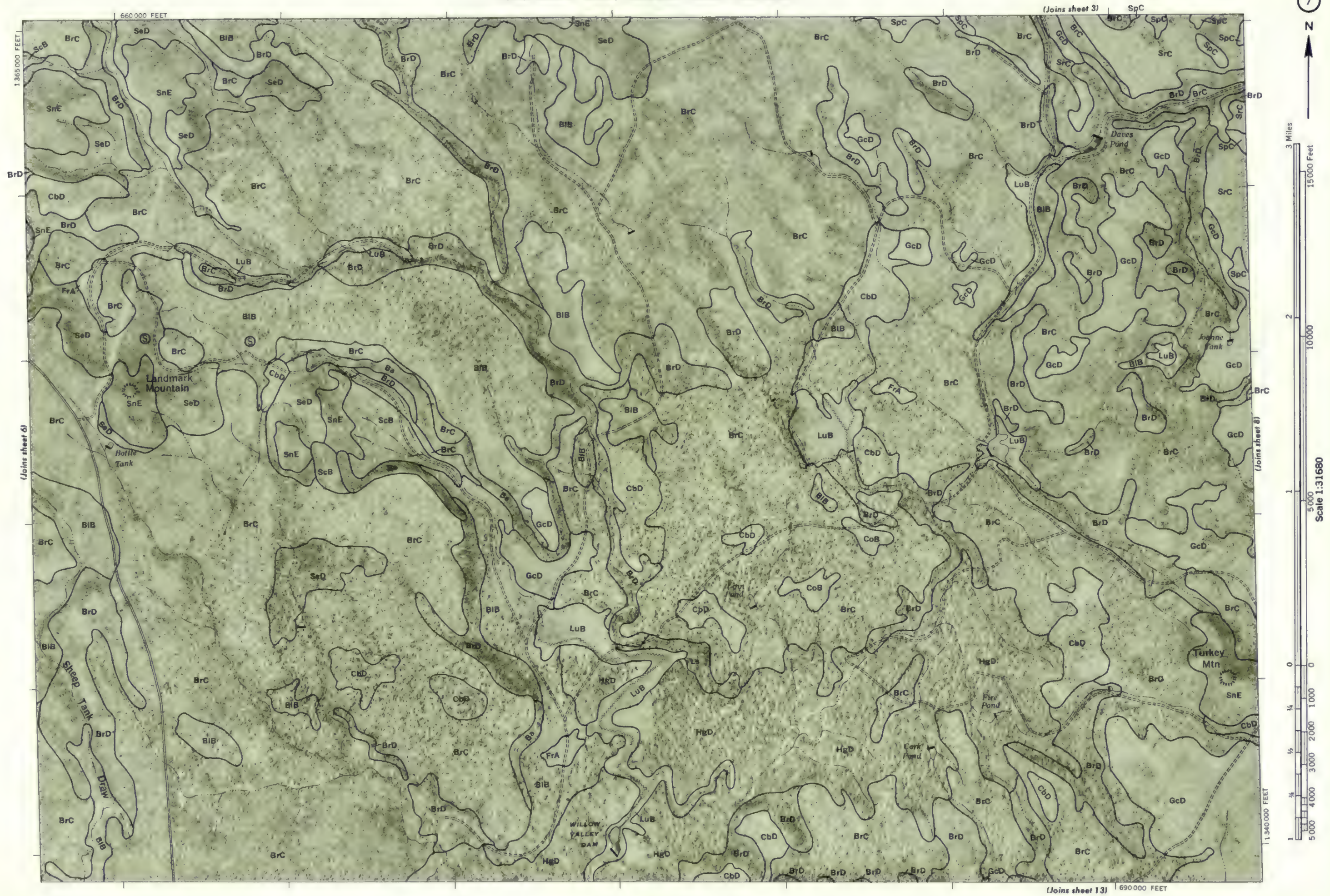
(Joins inset B)



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LONG VALLEY AREA, ARIZONA NO. 6

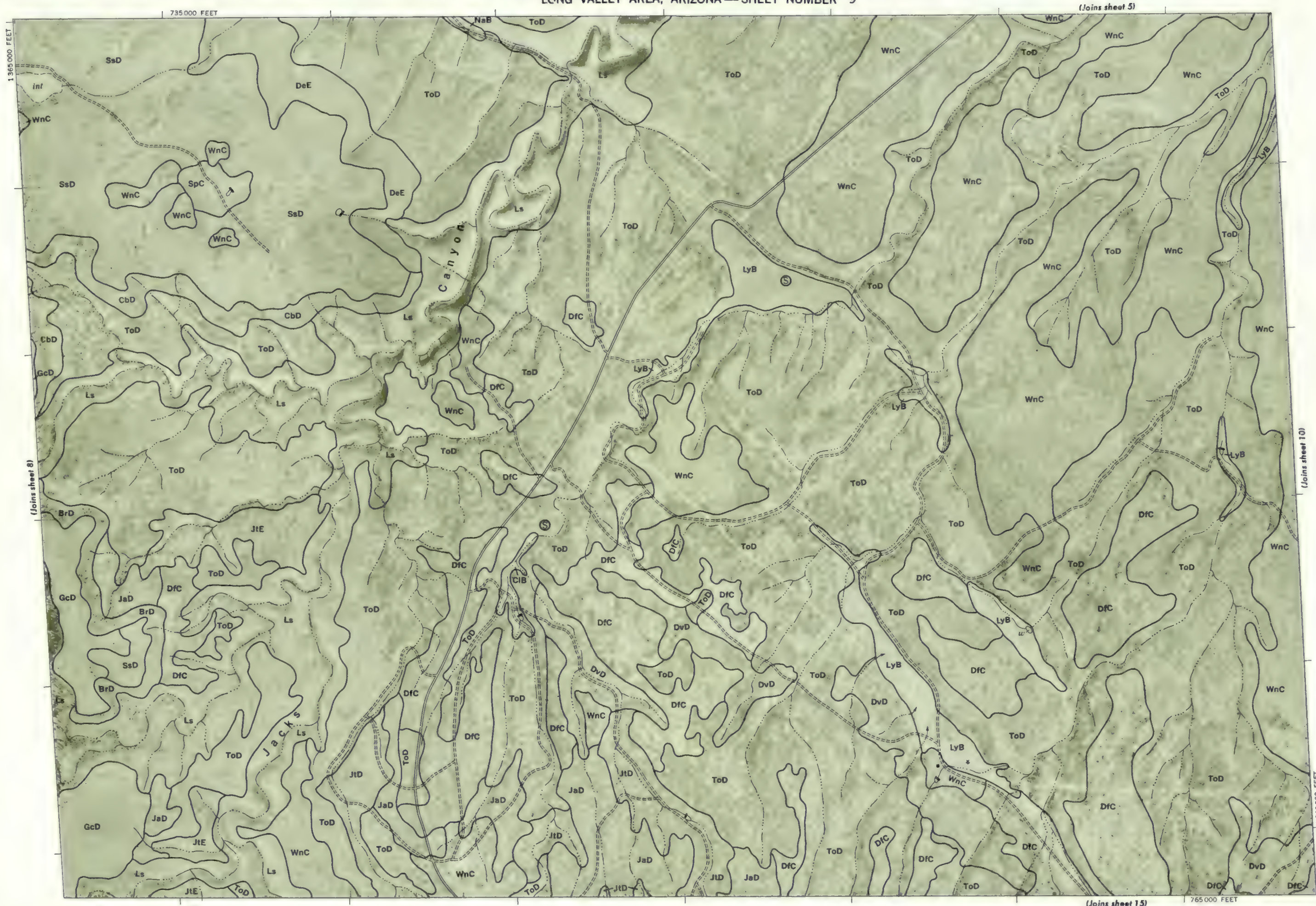
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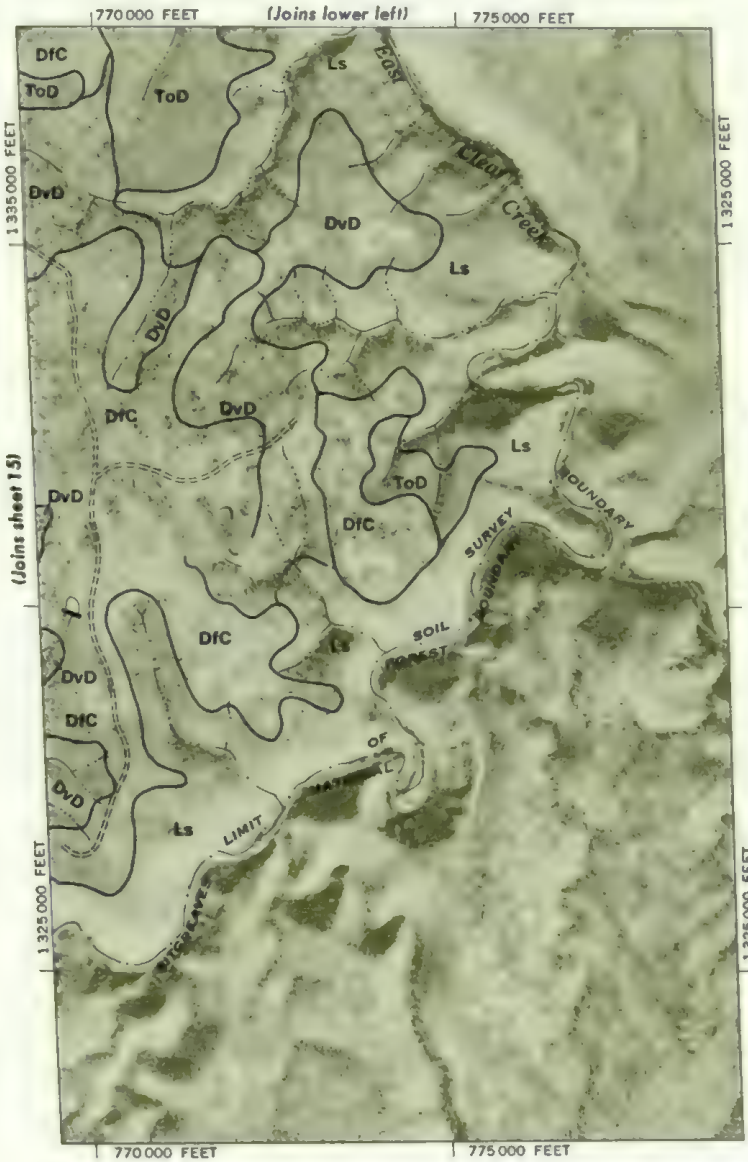
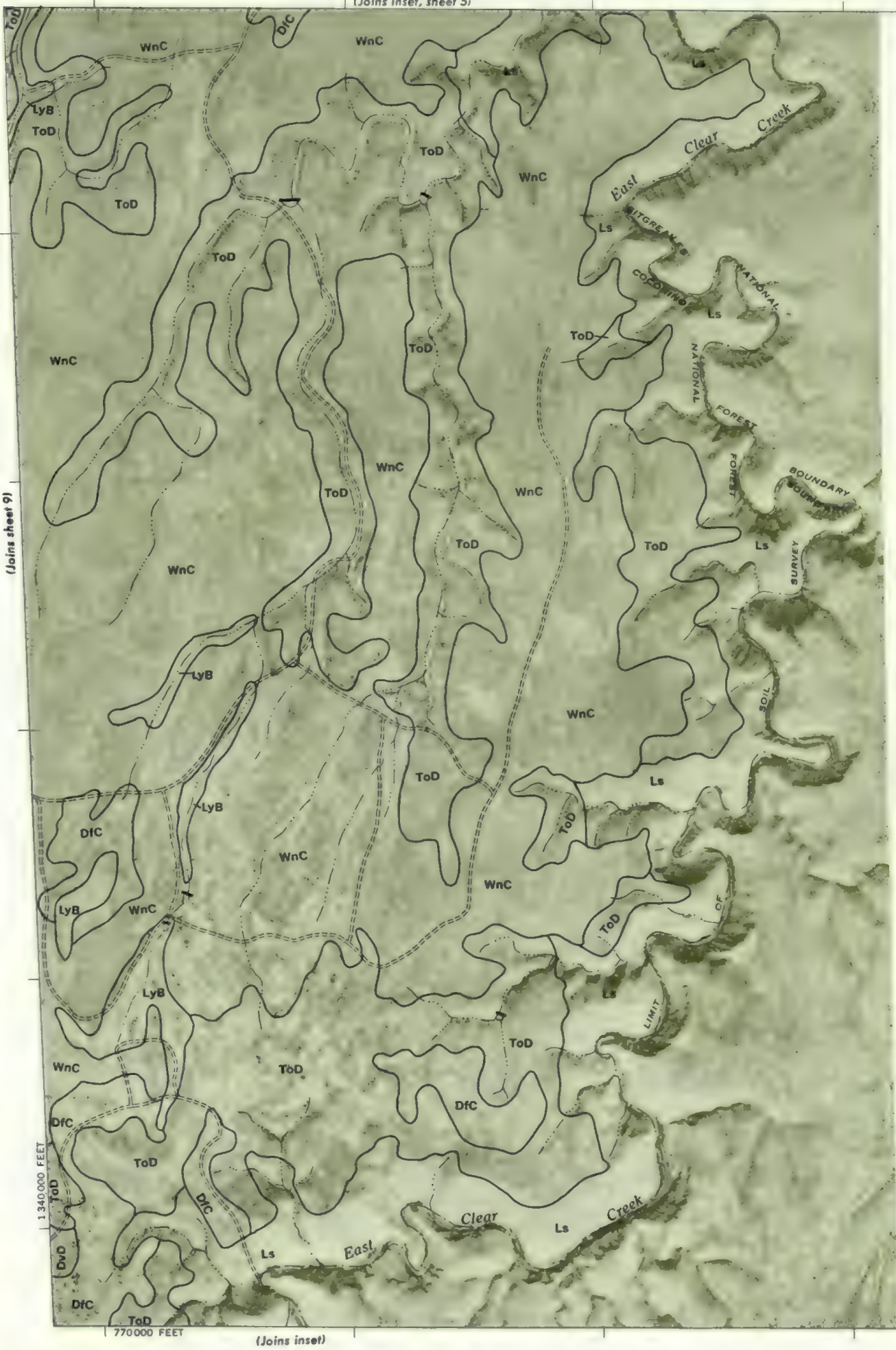




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1335,000 FEET

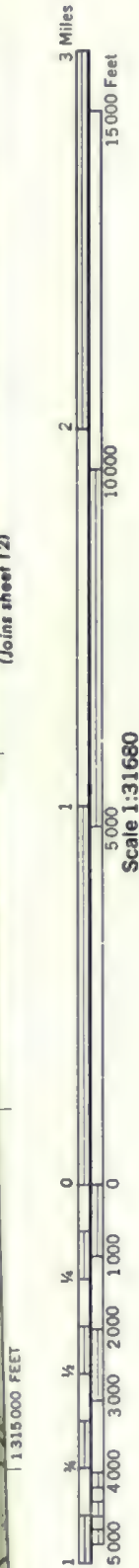
585,000 FEET



(Joins sheet 18)

620,000 FEET

(Joins sheet 12)





3 Miles

15,000 Feet

2

10,000

5,000

1

500

0

0

1,000

2,000

3,000

4,000

5,000

1

1/4

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3/4

1

1/4

1/2

3/4

1

Scale 1:31680



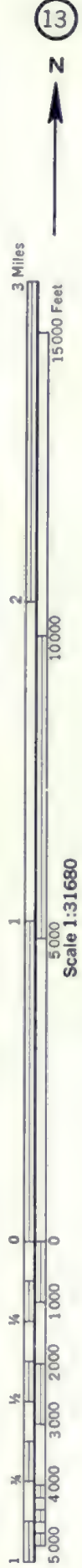
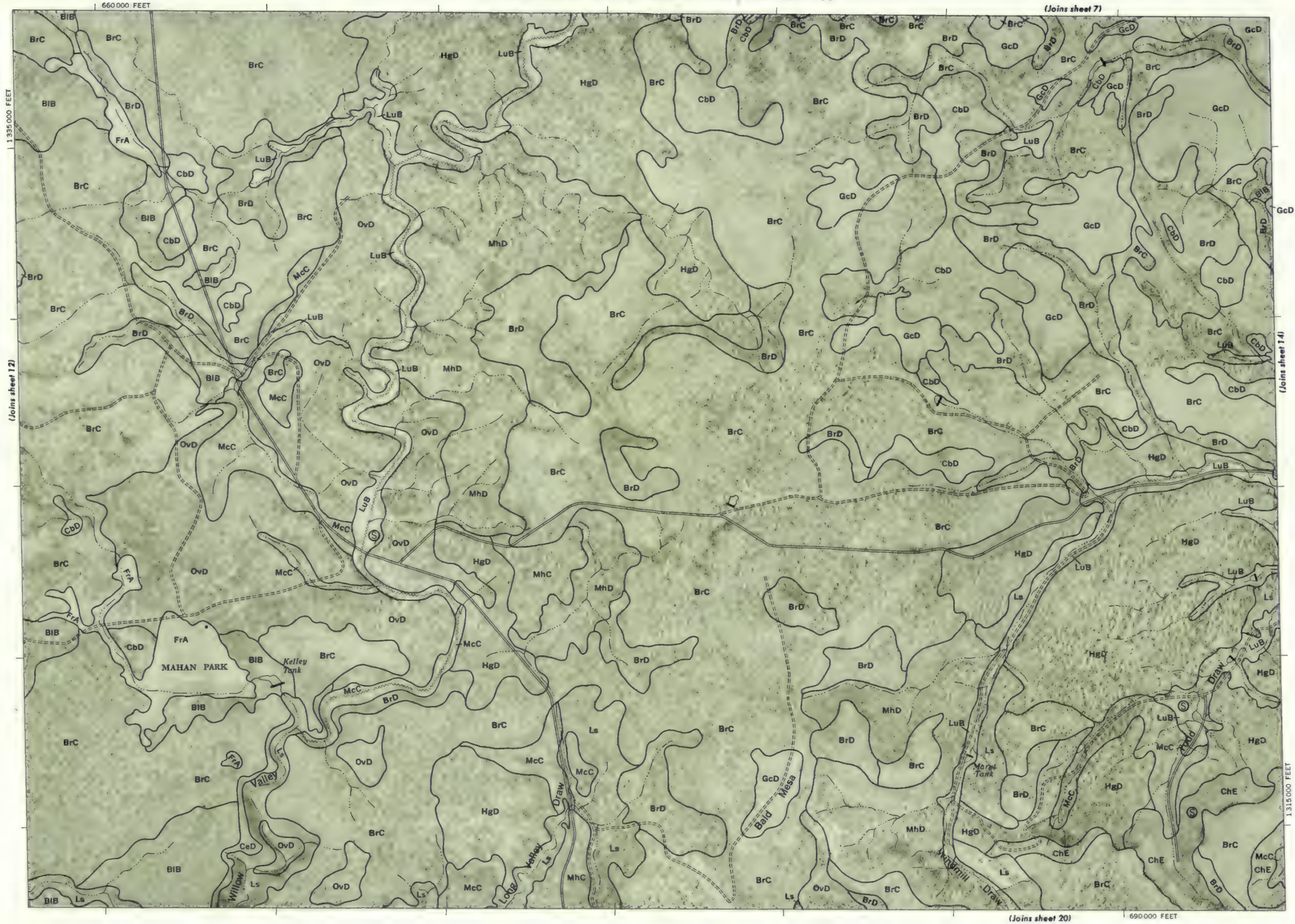
(Joins sheet 13)

(Joins sheet 19)

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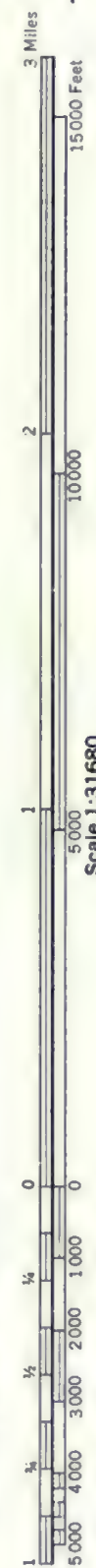
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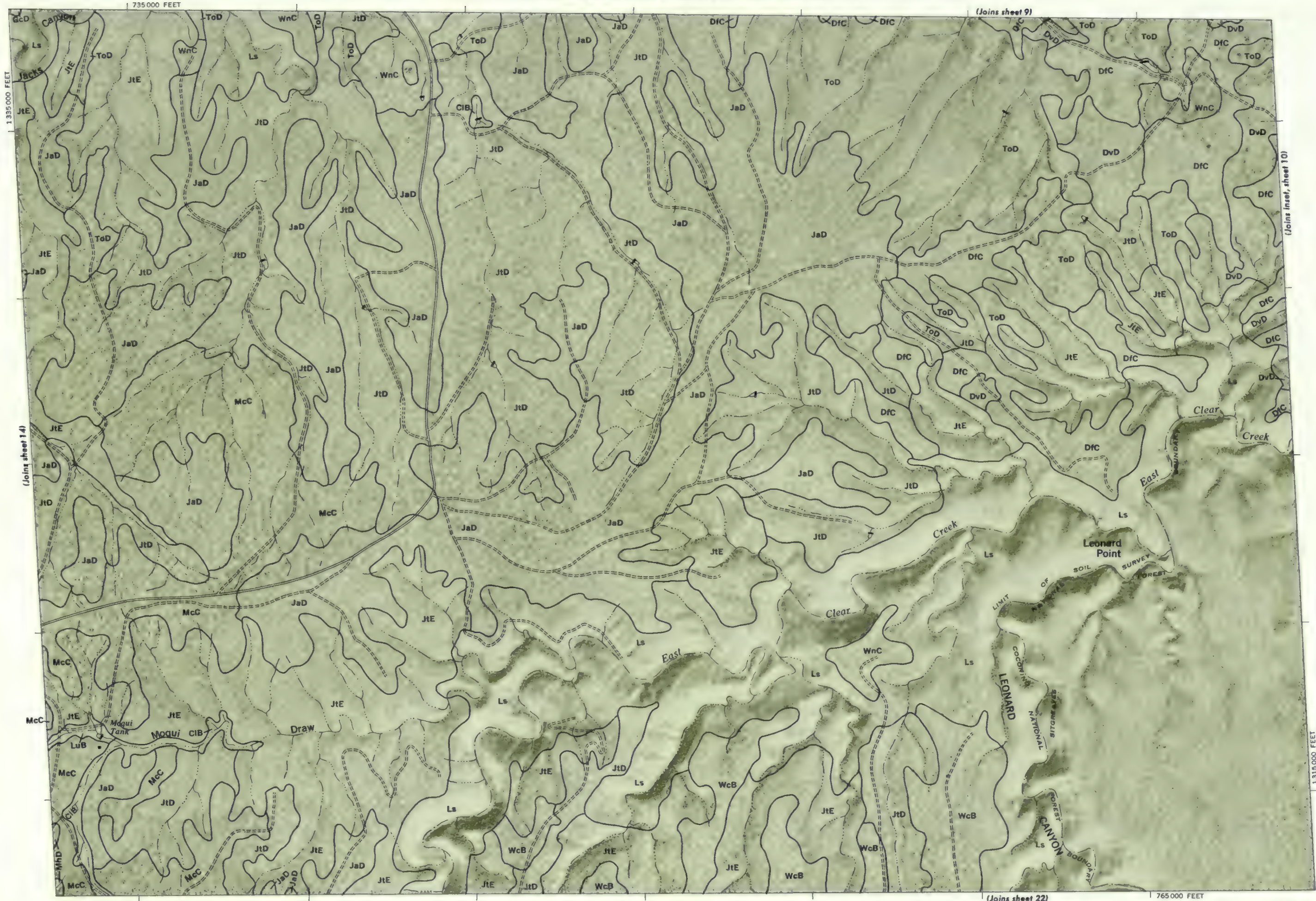
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LONG VALLEY AREA, ARIZONA NO. 15

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The area shown on this map sheet is part of the Coconino National Forest.

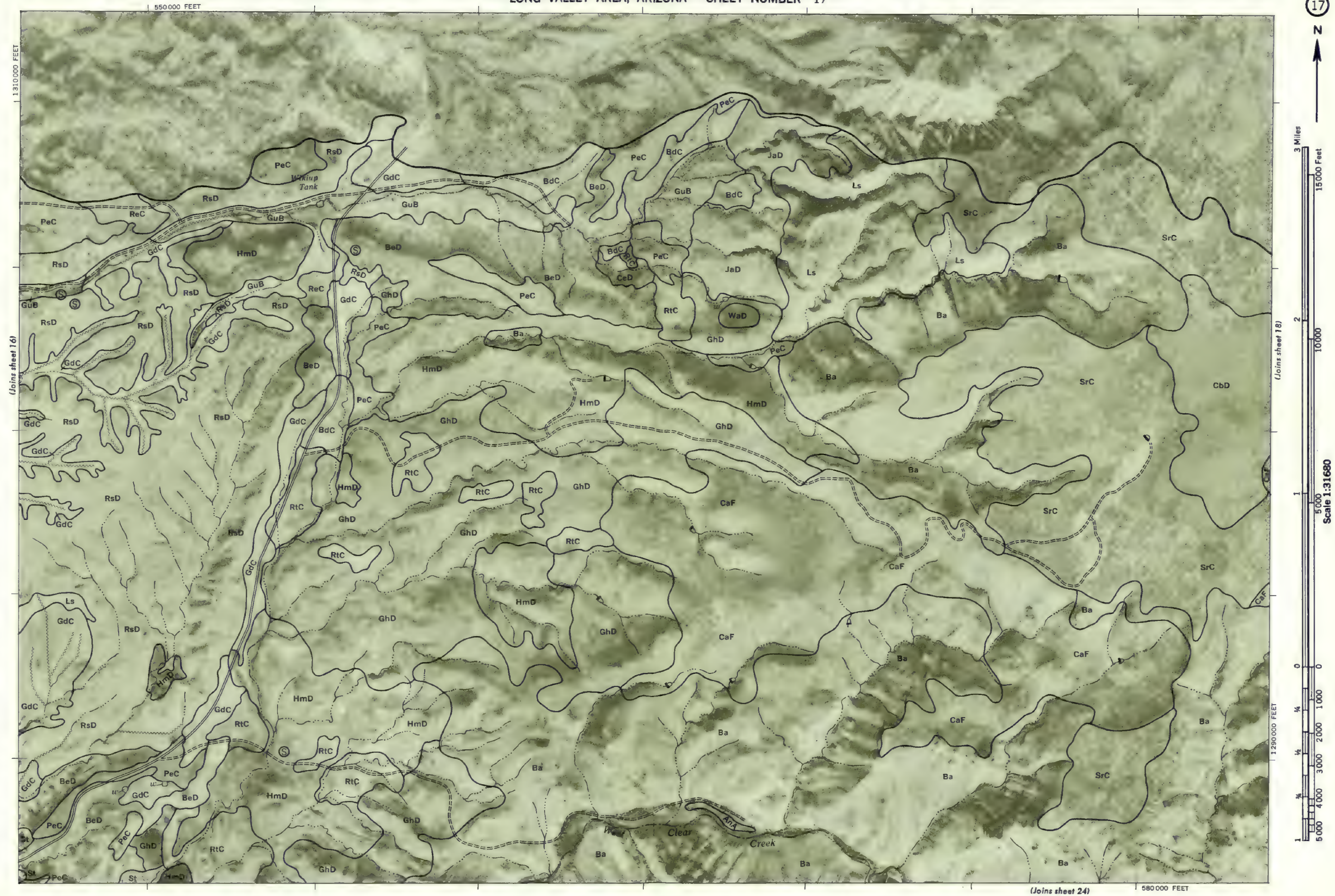




The area shown on this map sheet is part of the Coconino National Forest. Photographs from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station.

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The area shown on this map sheet is part of the Coconino National Forest.





3 Miles

15000 Feet

2

10000

1

5000

Scale 1:31680

0

0

1000

2000

3000

4000

5000

1

1/4

1/2

3/4

1

(Joins sheet 17)

1290000 FEET

585000 FEET

(Joins sheet 25)

(Joins sheet 19)

Ba



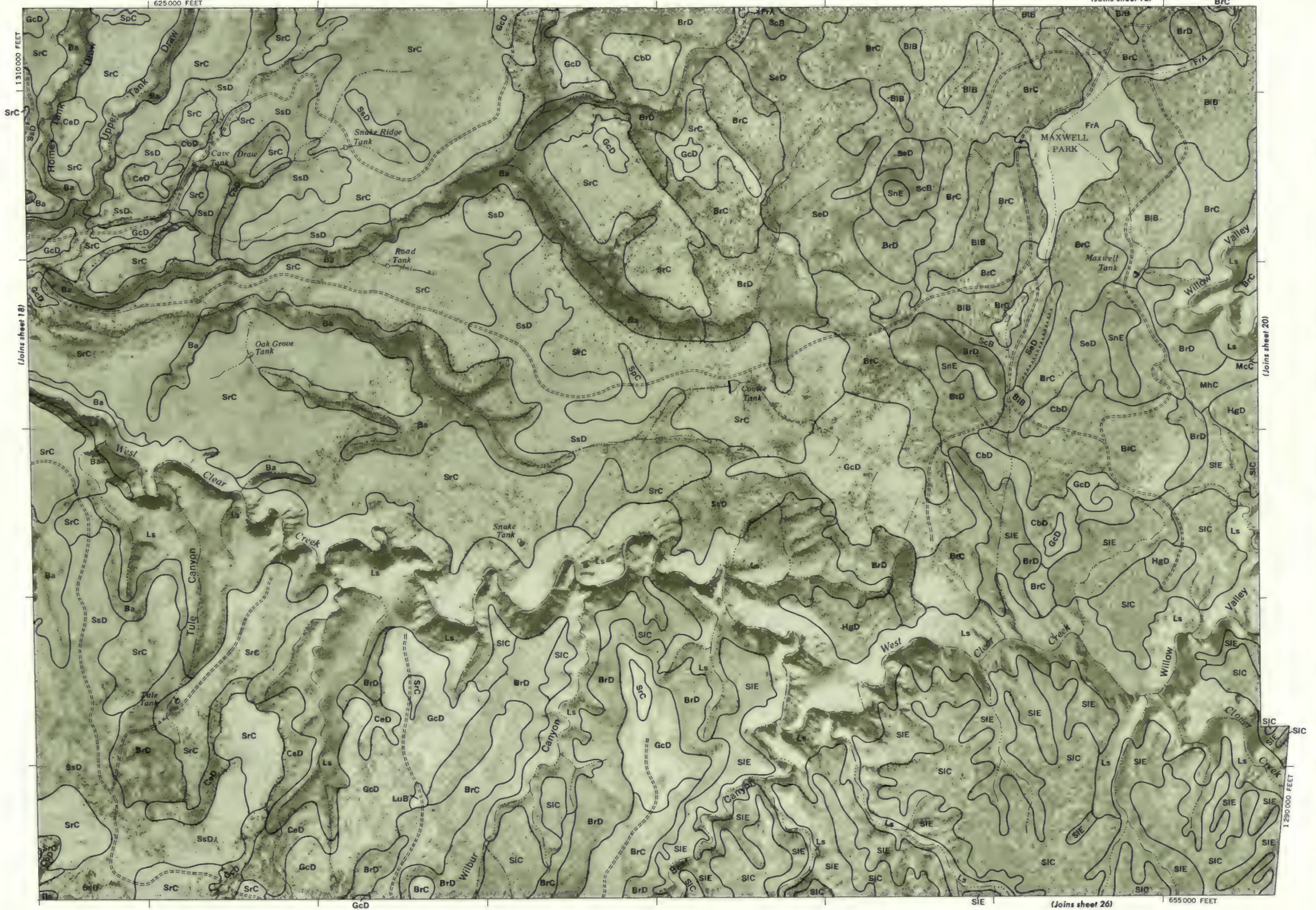
LONG VALLEY AREA, ARIZONA NO. 19

This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.

LONG VALLEY AREA, ARIZONA—SHEET NUMBER 19

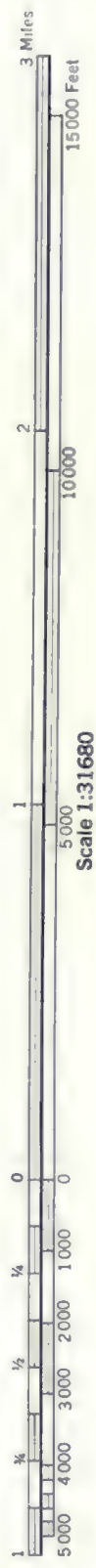
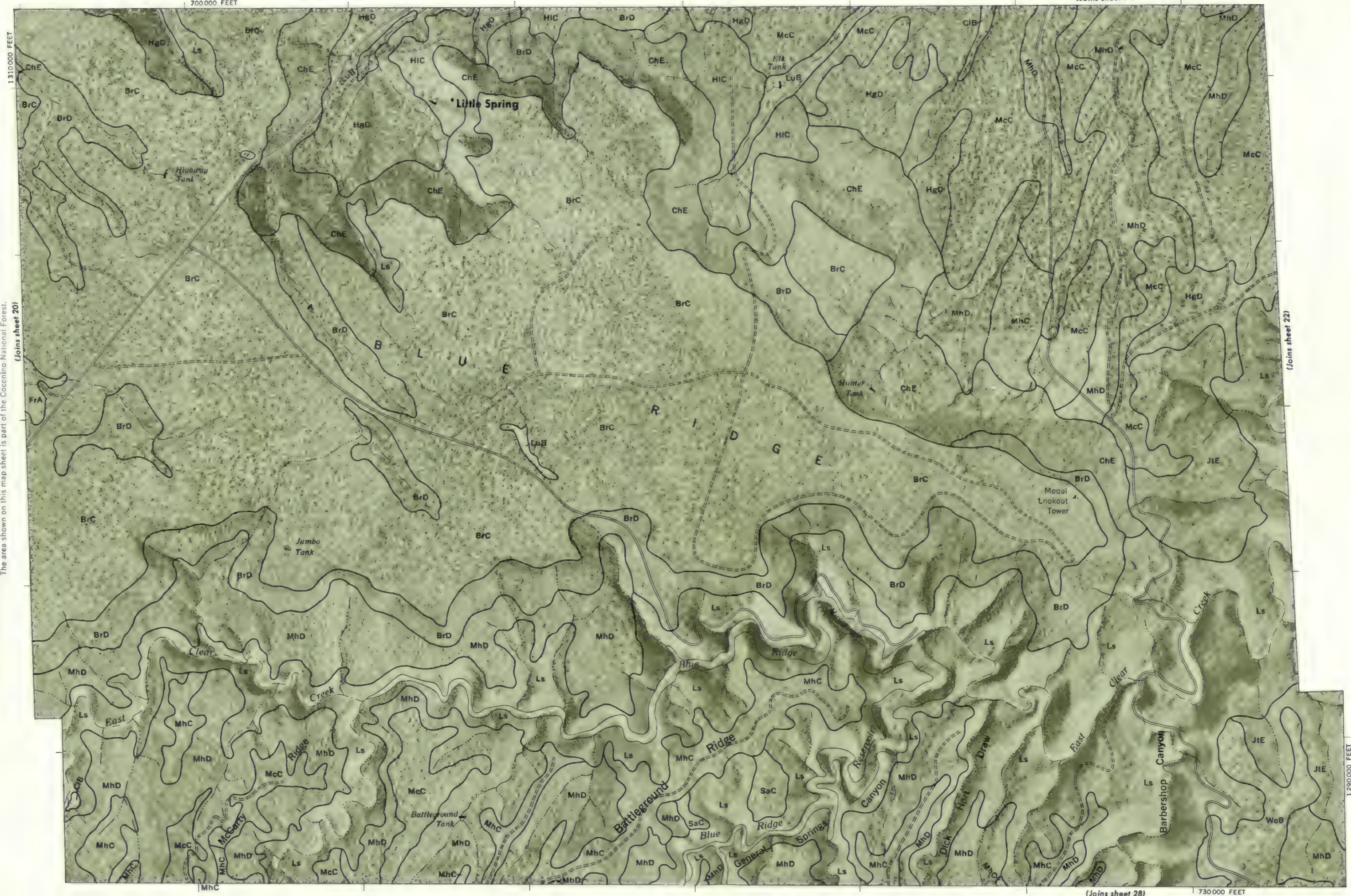
(Joins sheet 12)

19





This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.



1310000 FEET

(Joins sheet 20)

(Joins sheet 22)

(Joins sheet 28)

730000 FEET



3 Miles

15000 Feet

10000

5000

Scale 1:31680

1

2

3

4

5

6

7

8

9

10

11

12

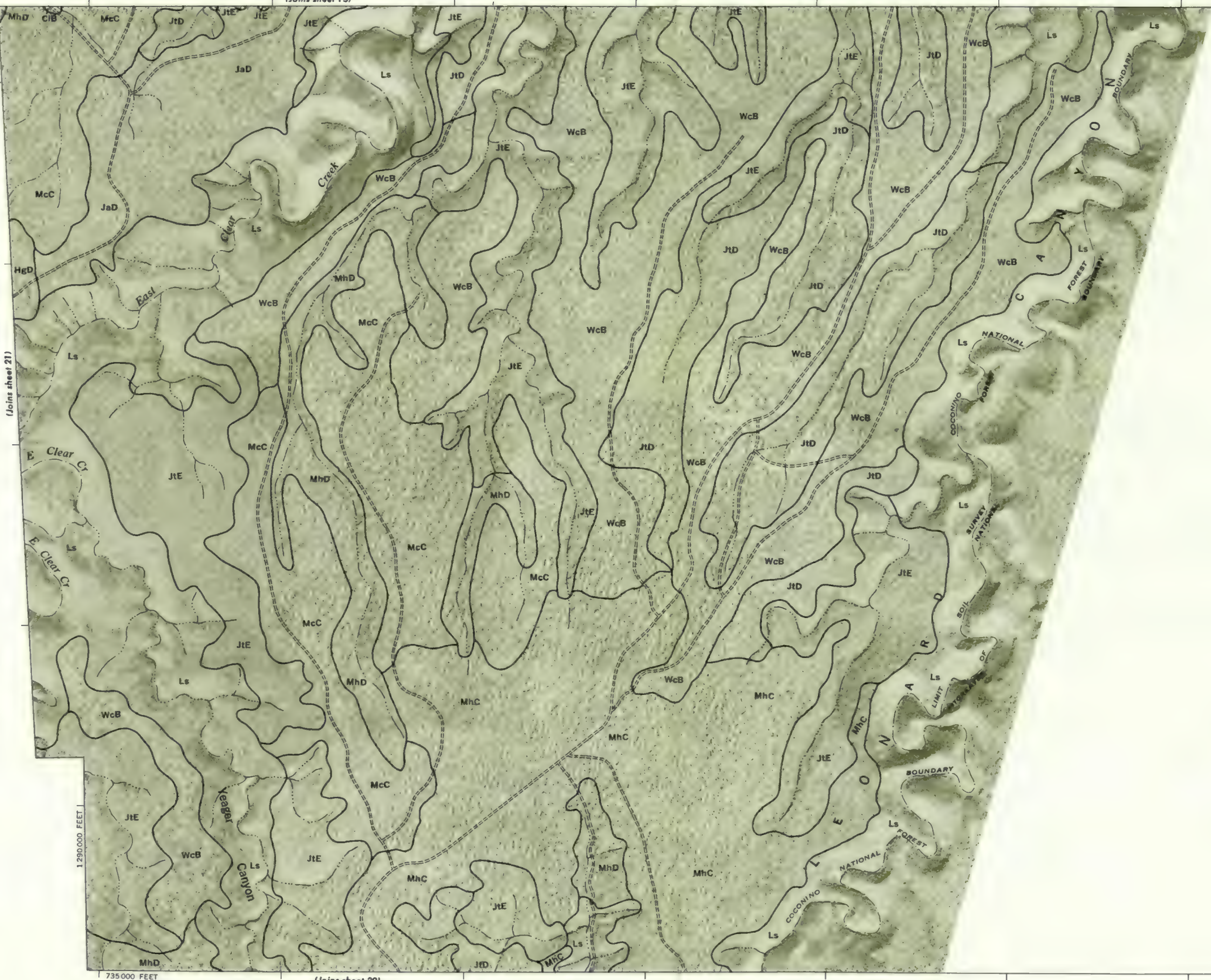
13

14

15

16

17

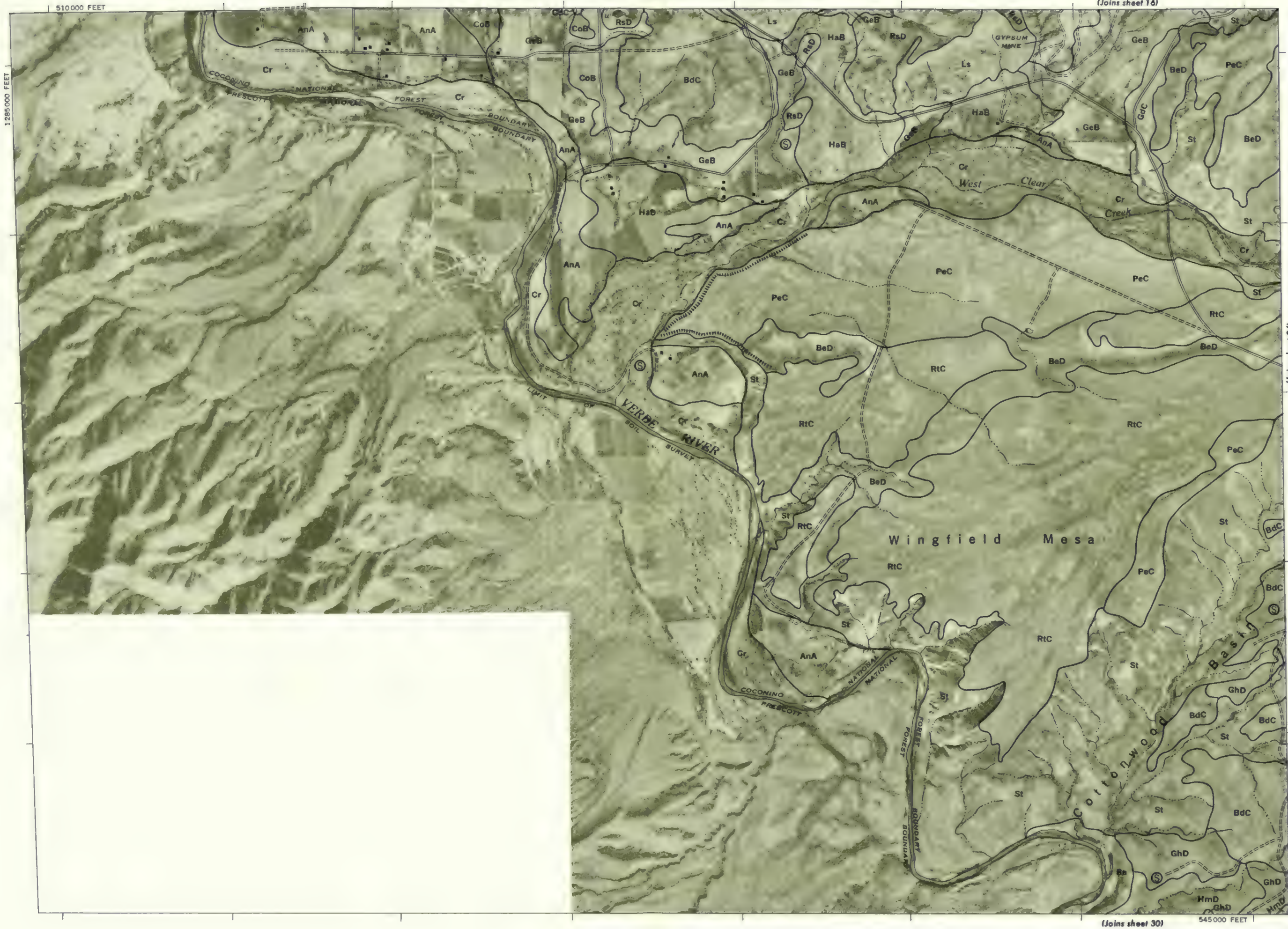
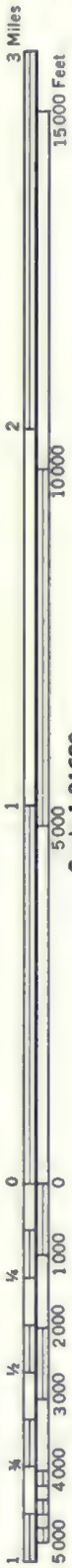


1310000 FEET

The area shown on this map sheet is part of the Coconino National Forest. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station.

LONG VALLEY AREA, ARIZONA NO. 22

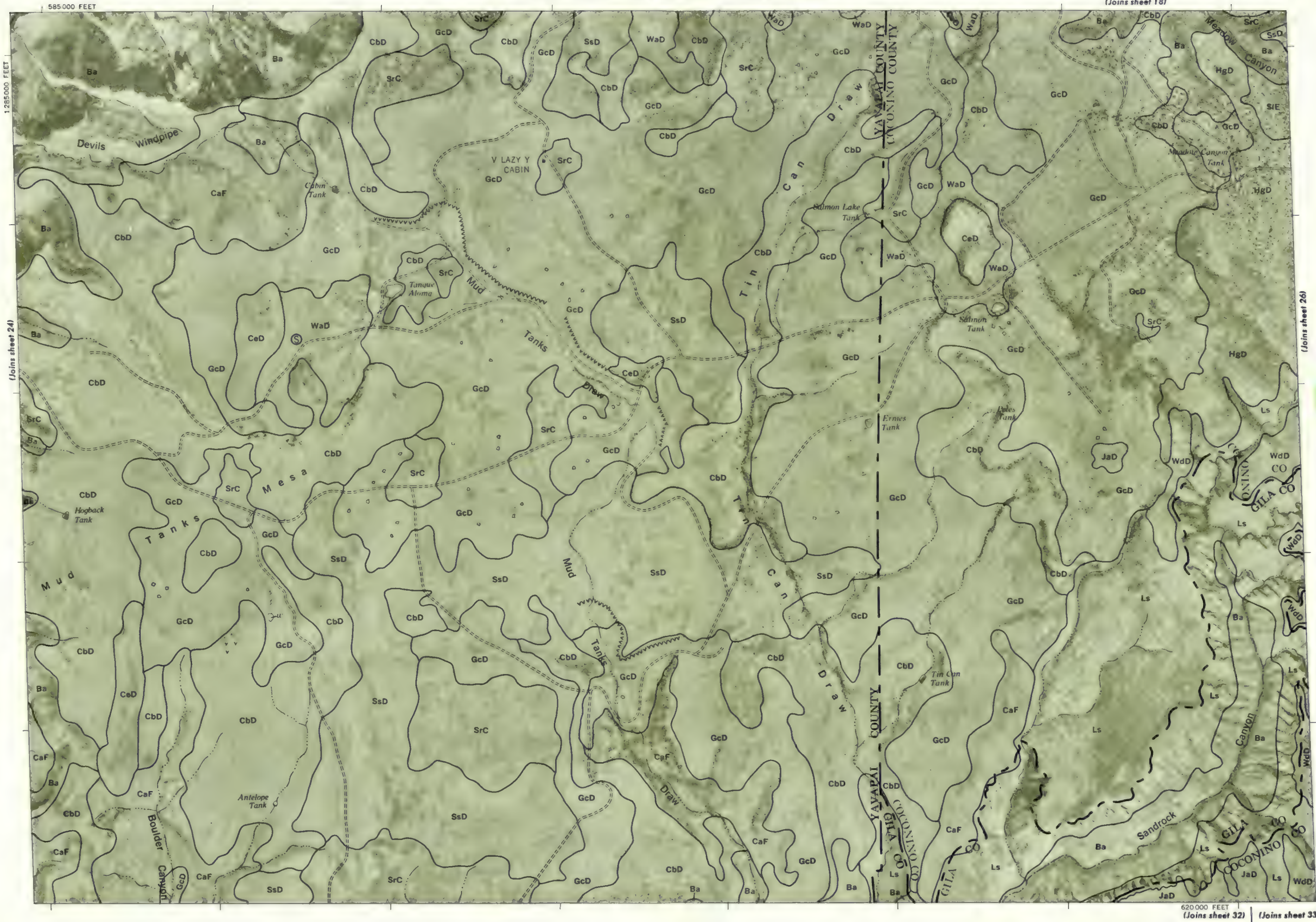
This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.

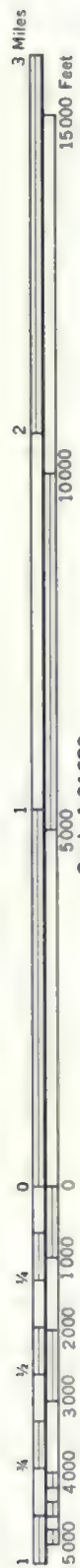




The area shown on this map sheet is part of the Coconino National Forest. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station.

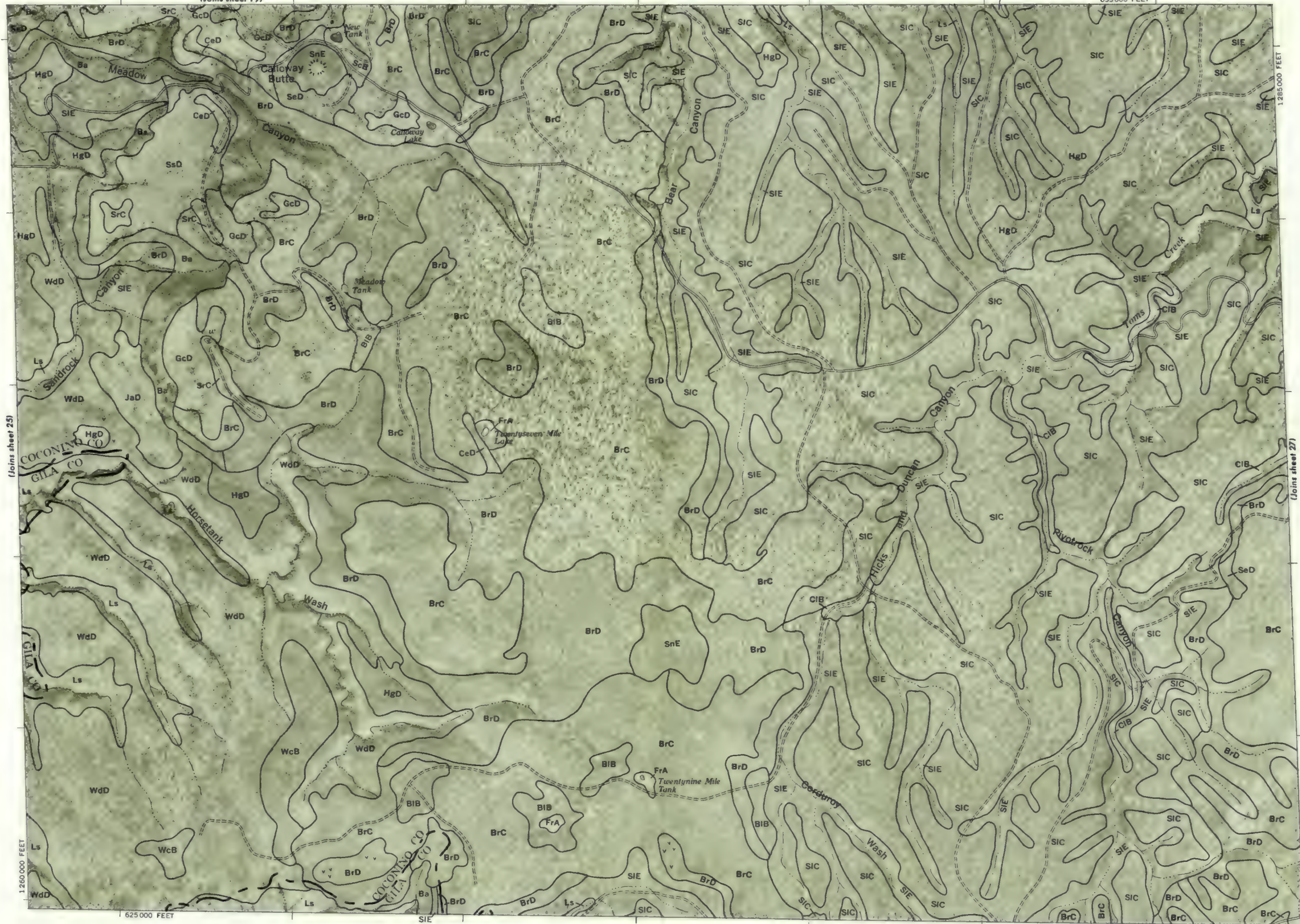
This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.





(Joins sheet 19)

655 000 FEET



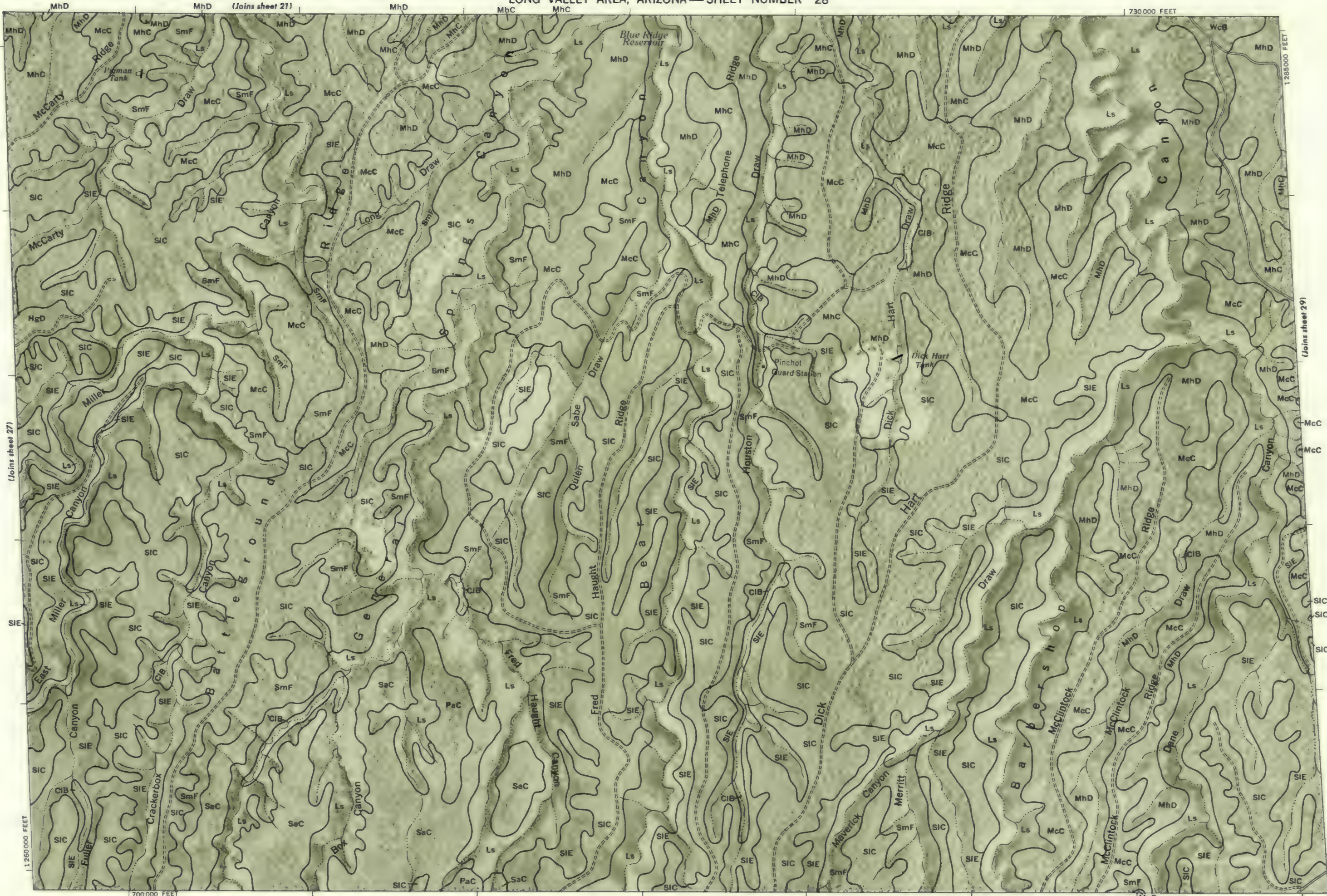
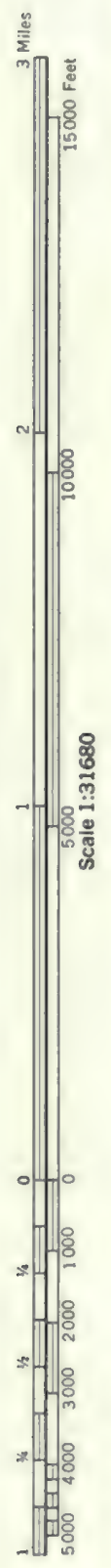
The area shown on this map sheet is part of the Coconino National Forest. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station.

LONG VALLEY AREA, ARIZONA NO. 26

The area shown on this map sheet is part of the Coconino National Forest.

27



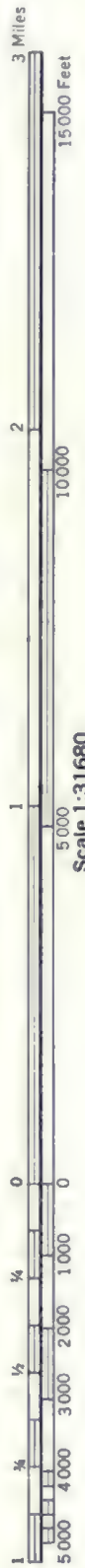


The area shown on this map sheet is part of the Coconino National Forest. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station.

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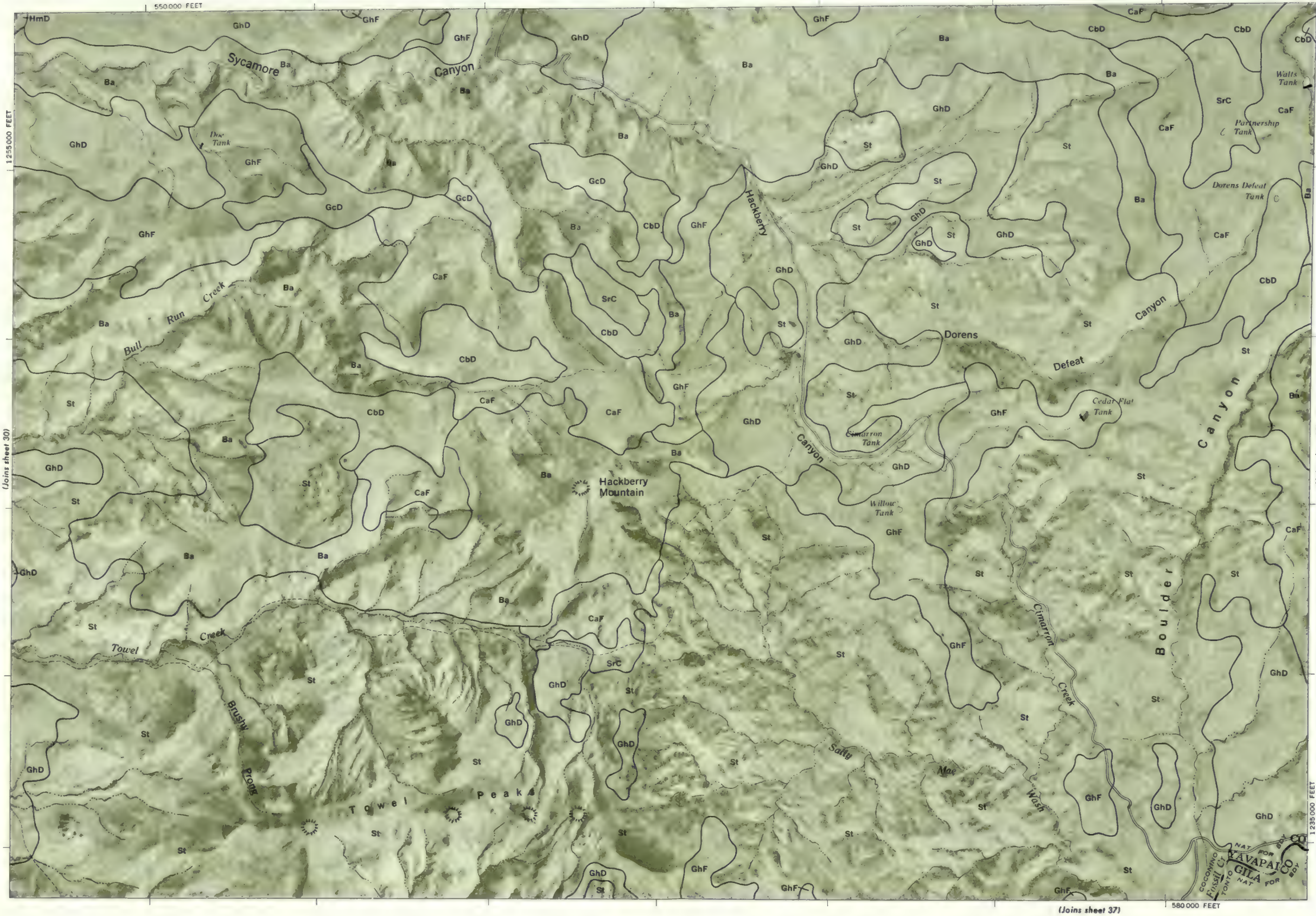
The area shown on this map sheet is part of the Coconino National Forest.





LONG VALLEY AREA, ARIZONA NO. 31

This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.



(Joins sheet 25)

620 000 FEET



3 Miles

15 000 Feet

2

10 000

1

5 000

0

1 000

1/4

2 000

1/2

3 000

3/4

4 000

1

Scale 1:31680

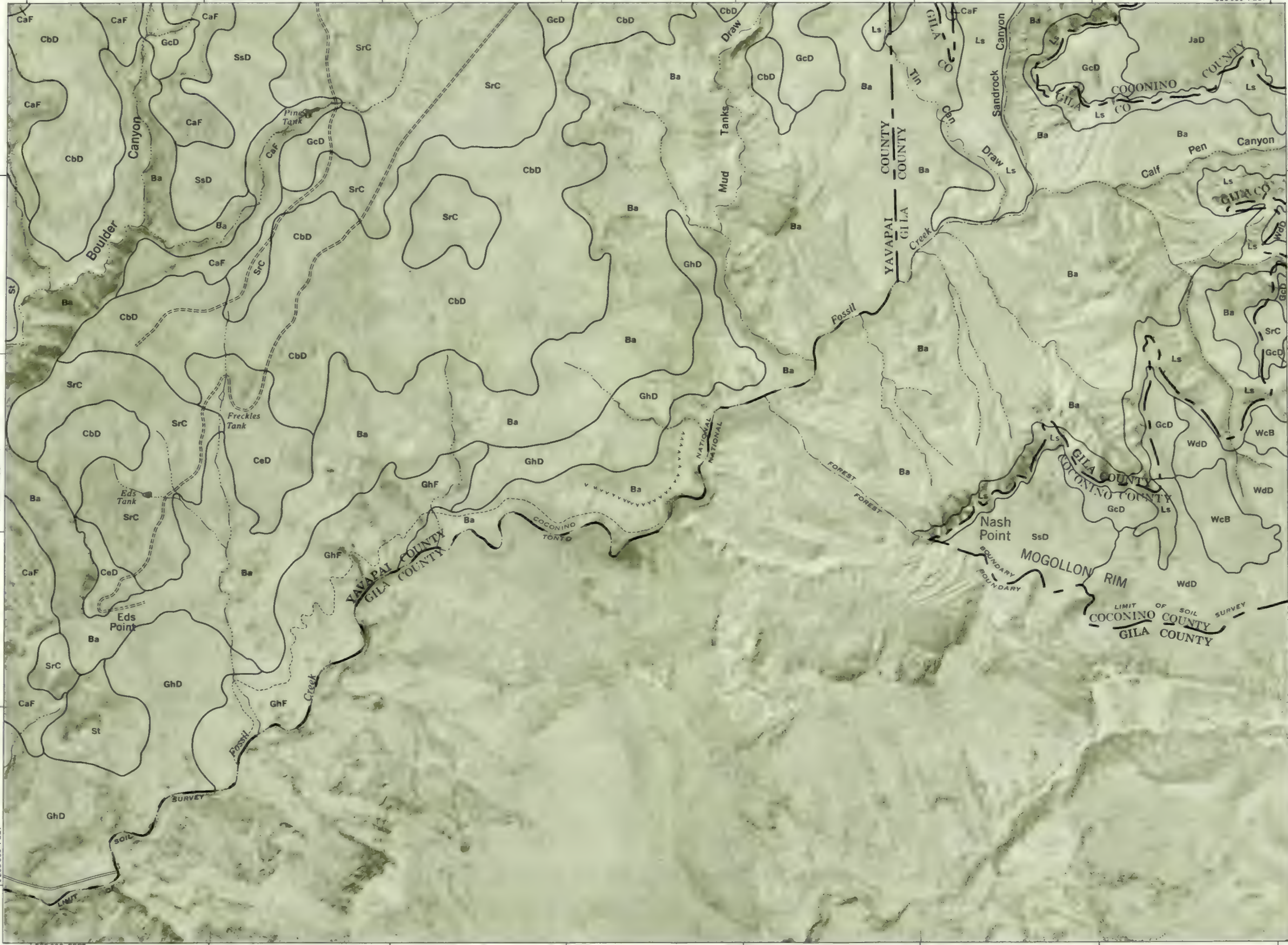
(Joins sheet 31)

1:235 000 FEET

585 000 FEET

(Joins sheet 33)

1 255 000 FEET



The area shown on this map sheet is part of the Coconino National Forest.

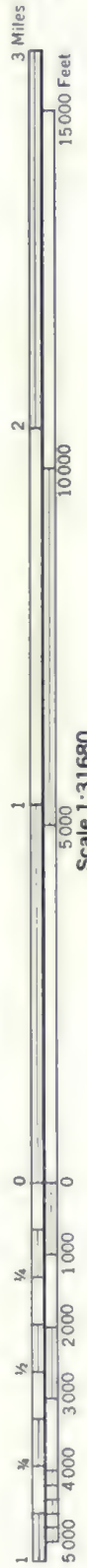
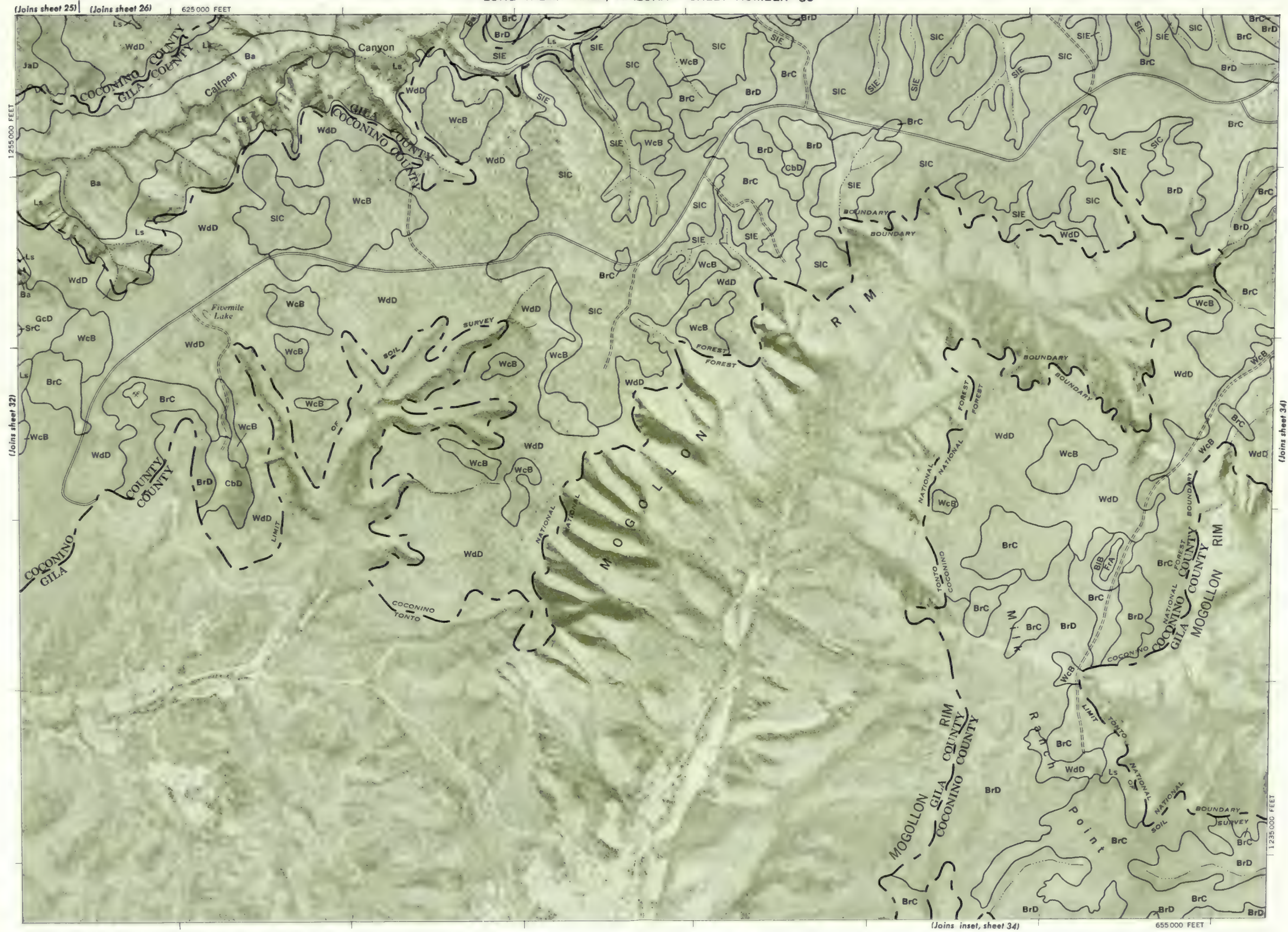
Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum.

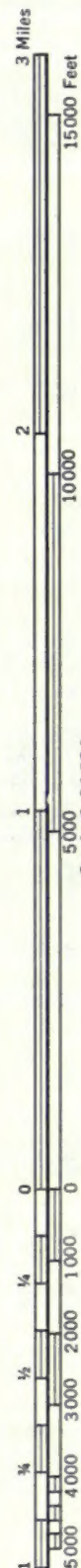
This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station.

LONG VALLEY AREA, ARIZONA NO. 32

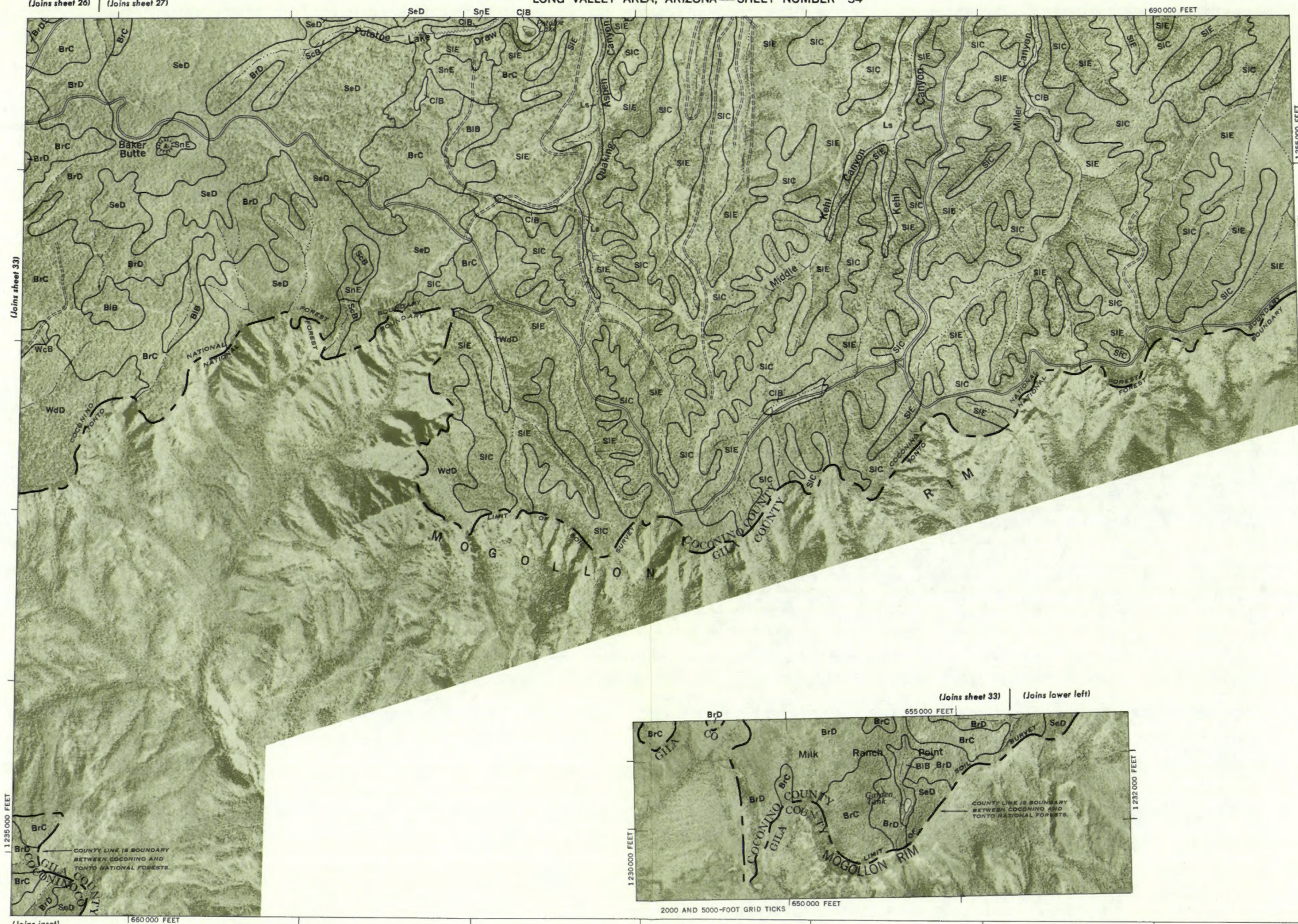
LONG VALLEY AREA, ARIZONA NO. 33

This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.



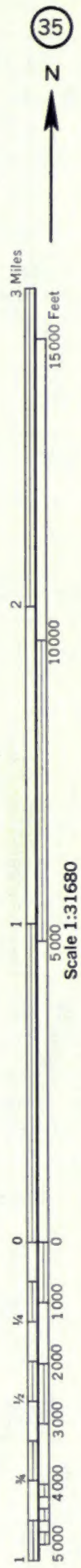
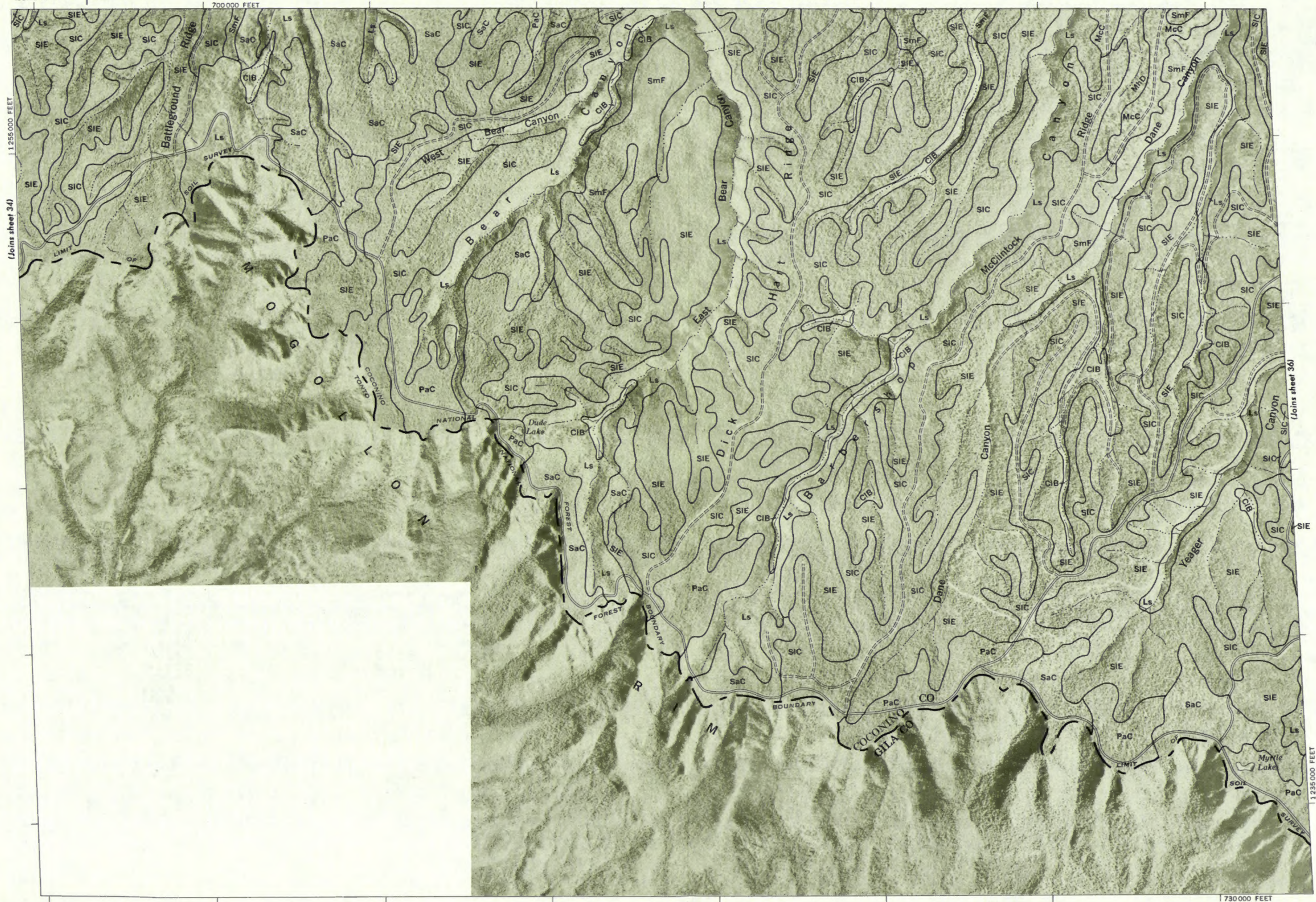


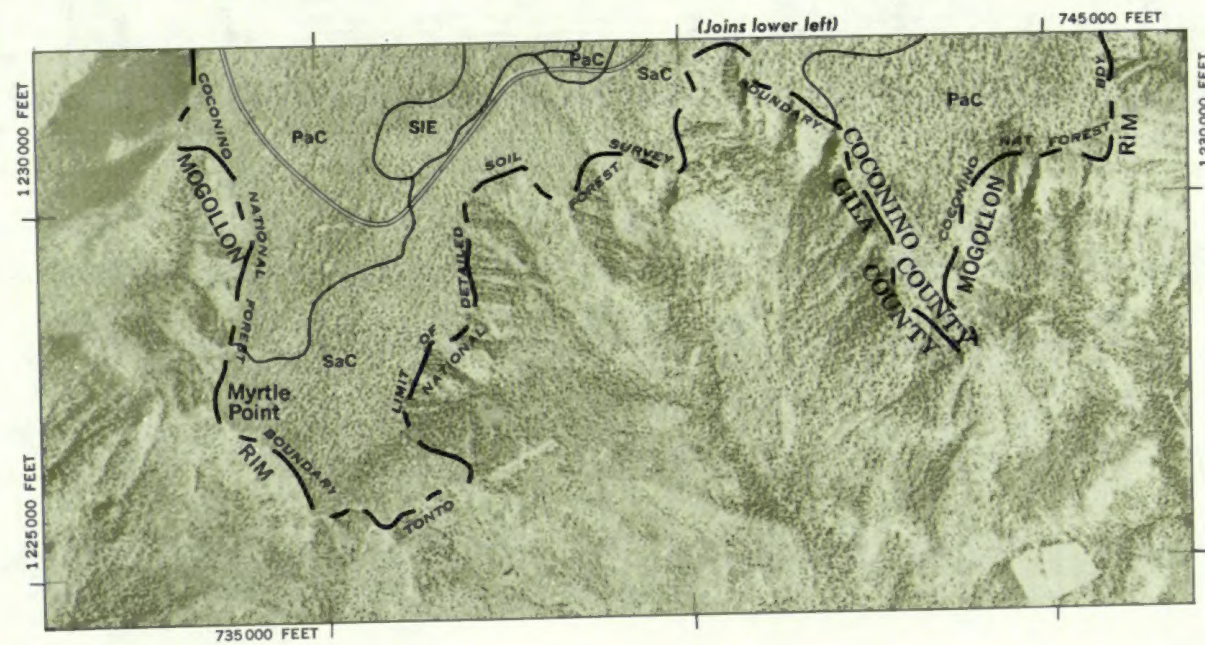
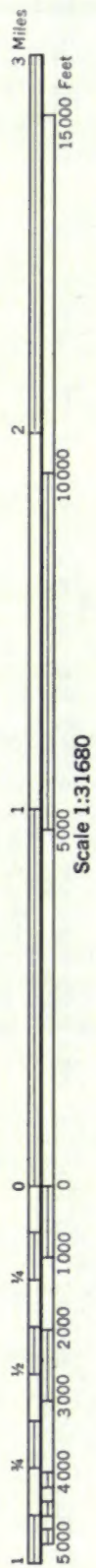
5 000
Scale 1:31680



This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Forest Service and Soil Conservation Service, and the University of Arizona Agricultural Experiment Station. Photobase from 1959-60 and 1962 aerial photographs. 5,000-foot grid ticks based on Arizona plane coordinate system, central zone, 1927 North American datum. The area shown on this map sheet is part of the Coconino National Forest.

(Joins sheet 27) (Joins sheet 28)





1255 000 FEET

1230 000 FEET

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LONG VALLEY AREA, ARIZONA NO. 37

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The area shown on this map sheet is part of the Coconino National Forest.

